

New Haven School Bus Retrofit Project

Final Report to the Connecticut Department of Environmental Protection



Prepared by NESCAUM

June 2006

CONTENTS

Executive Summary	3
1. Introduction	6
2. Fleet Survey	7
3. Exhaust Temperature Data Logging	8
4. Selection of Emission Control Technology	11
5. Installation of Technology	13
6. Estimated Emissions Reductions	16
7. Education and Media Outreach	17
8. Conclusions	18
Appendix 1: Project Participants	19
Appendix 2: Estimated Emissions Reductions from Spiracle CCV + DOC	20
Appendix 3: Agenda for Vendor Workshop, February 25, 2004	21
Appendix 4: Request for Proposals, May 19, 2004	24

ABBREVIATIONS

- CCV – Closed Crankcase Ventilation
- CO – Carbon Monoxide
- DOC – Diesel Oxidation Catalyst
- DPF – Diesel Particulate Filter
- ECT – Emission Control Technology
- EGT – Exhaust Gas Temperatures
- FBC – Fuel-Borne Catalyst (fuel additive)
- HC – Hydrocarbon
- NOx – Nitrogen Oxides
- PM – Particulate Matter

EXECUTIVE SUMMARY

This report summarizes the results of a project to equip the First Student school bus fleet in New Haven, Connecticut, with emission control technologies. The project, which began in 2004, set a goal of retrofitting 181 conventional, front-engine diesel school buses with pollution controls to achieve the greatest possible long-term reduction in particulate matter (PM), hydrocarbon (HC), and carbon monoxide (CO). The retrofit project is part of the Connecticut Department of Environmental Protection's (CT DEP) *Clean School Bus Program*.

The need for reducing emissions from heavy-duty diesel engines, and from diesel school buses in particular, is clear. Current inventories estimate that emissions from heavy-duty diesel engines comprise 34 percent of all nitrogen oxide (NO_x) pollution, 43 percent of PM₁₀, and 56 percent of fine particulate matter (PM_{2.5}) from on-road sources in the Northeast states.¹ Diesel exhaust poses a significant risk to human health, as it contains more than 40 chemicals listed as Hazardous Air Pollutants under the Clean Air Act and was recently classified as the sixth most potent carcinogenic substance reviewed by California's Scientific Review Panel.² The HC and NO_x emissions in diesel exhaust are ozone precursors that contain known carcinogens and that can also exacerbate cardiopulmonary diseases. The PM_{2.5} in diesel emissions is known to aggravate respiratory illnesses such as asthma, emphysema, and bronchitis and is also linked to lung cancer. Children are especially susceptible to the risks associated with diesel emissions, because their immune and respiratory systems are still developing and they breathe up to 50 percent more air per pound of body weight than adults. For these reasons, the *New England Journal of Medicine* reports that exposure to air pollution may cause chronic decreases in lung function by age 18.³

Children riding on diesel school buses are exposed to elevated levels of harmful emissions. Recent studies have documented high levels of PM_{2.5} and other toxins in school bus cabins.⁴ In Connecticut nearly 387,000 children ride approximately 6,500 school buses each day, and 90 percent of those buses run on diesel fuel. While more stringent emissions standards for newly manufactured diesel engines will go into effect in 2007, older high-emitting diesels will be on the road for many years. Reducing children's exposure to diesel pollution therefore requires an emission control strategy for those older

¹ Source: Mid-Atlantic/Northeast Visibility Union (MANE-VU) RPO 2002 Emissions Inventory, Version 2 E1; <http://www.marama.org/visibility/Inventory%20Summary/2002EmissionsInventory.htm>.

² State of California, "Findings of the Scientific Review Panel on The Report on Diesel Exhaust," April 22, 1999; cited in Environment & Human Health, Inc., "Children's Exposure to Diesel Exhaust on School Buses," 2002.

³ W.J. Gauderman, et al., "The Effect of Air Pollution on Lung Development from 10 to 18 Years of Age," *New England Journal of Medicine* 351(11), Sept. 9, 2004, and a related study of truck density and "black smoke" inside schools: B. Brunekreef, et al., "Air Pollution from Truck Traffic and Lung Function in Children Living Near Motorways," *Epidemiology* 8(#):298-303. Both cited in New Jersey Department of Environmental Protection, "Gasping for Breath?" brochure.

⁴ Clean Air Task Force, "CATF School Bus Particulate Matter Study," 2005; and California Air Resources Board, "Children's School Bus Exposure Study," 2003.

bus engines, including retrofitting them with advanced pollution controls and establishing and enforcing anti-idling programs.

The *New Haven School Bus Retrofit Project* was undertaken by CT DEP in conjunction with the New Haven Board of Education, City of New Haven, and U.S. Environmental Protection Agency (EPA). First Student, Inc. and the Connecticut Department of Motor Vehicles (DMV) also contributed to the project's success. Northeast States for Coordinated Air Use Management (NESCAUM) was hired by CT DEP to manage the project. All 181 buses included in the project are owned and operated by First Student, Inc., which has a contract with the New Haven Board of Education to transport children to and from elementary, middle, and parochial schools in the city. Funding for the project came from supplemental environmental project (SEP) funds.

There were six components to the *New Haven School Bus Retrofit Project*: 1) fleet survey; 2) exhaust temperature data logging; 3) selection of emission control technology; 4) technology installation; 5) estimate of emissions reductions; and 6) education and media outreach.

Results

Initial information from the fleet survey suggested that the relatively new First Student school buses would be good candidates for diesel particulate filters (DPFs), which achieve the greatest reduction in particulate matter, and for closed crankcase ventilation (CCV) systems to reduce in-cabin pollution from the crankcase emissions typical of the turbocharged engines used in the fleet. However, the recorded exhaust temperature of three buses tested during several runs on their typical routes was below 240 degrees Celsius for a significant portion of their daily duty cycle. For DPFs to regenerate properly, engine exhaust must be at least 240 degrees Celsius for 60 percent of the duty cycle; at lower temperatures the filters are likely to plug with soot and cause a loss of engine power.

A committee composed of representatives from CT DEP, City of New Haven, New Haven Board of Education, First Student, EPA Region 1, and NESCAUM established criteria for selecting emission control technology for this fleet, issued an RFP (see Appendix 4), and reviewed proposals from five vendors for alternatives to diesel particulate filters. The committee focused on two issues: reducing tailpipe emissions effectively without technologies that need high exhaust temperatures; and reducing in-cabin pollution from the crankcase emissions typical of the turbocharged engines used in the First Student fleet. Also considered were capabilities in the areas of technical management, emission control technology (ECT) pilot program, ECT technical merit and feasibility, ECT environmental benefits, project support, training, timetable for delivery, budget, and affirmative action. After careful review, the committee selected two vendors: Donaldson Company, Inc. to supply a combination of its 6100 series diesel oxidation catalyst (DOC) and its Spiracle CCV system for all 181 buses; and Clean Diesel Technologies, Inc. to dose the entire fleet (including an additional 69 Type A vehicles) with its Platinum Plus fuel-borne catalyst (FBC).

Donaldson Company provided training and guidance manuals to the maintenance staff at First Student. Installation initially took longer than expected, as the team needed to make design changes to ensure a proper fit on the school buses. Those changes included retooling the DOC, reconfiguring and cutting the exhaust pipe, and reengineering the support bracket for the Spiracle so that it could fit on the front-left of the cylinder head of the engine, rather than hang from the radiator. In addition, dosing with the fuel-borne catalyst was stopped after a month because of incomplete information about the effects of possible increases in platinum emissions and concerns raised by EPA. The literature has data only on the health impacts from large doses of platinum in emissions, and the lack of information about exposure to small doses prompted the team to discontinue the dosing part of the retrofit program.

The Donaldson Spiracle + DOC is an EPA-verified technology rated to attain up to a 28 percent reduction in combined tailpipe and crankcase PM emissions. The EPA verification program provides conservative estimates of emissions reductions,⁵ however; anticipated reductions in New Haven are 32 percent for PM, 42 percent for HC, and 34 percent for CO. The estimated annual reduction for the fleet is 471 lbs/yr of PM, 8018 lbs/yr of HC, and 77,359 lbs/yr of CO. The anticipated service life of these buses is approximately 7 years; over the life of the fleet, therefore, the project will reduce 1 ton of PM, 18 tons of HC, and 174 tons of CO from the New Haven school bus fleet.⁶

Finally, there were two education and media outreach activities. The first was a workshop for the project team in which vendors of emission control technologies described their products. The second was a press conference launching the retrofit project and unveiling an air-quality curriculum for middle school students that was developed by CT DEP.

⁵ The EPA verification process is intended to establish SIP creditable emission reductions (states can claim up to 3 percent of needed SIP credits through voluntary programs), which makes states responsible for achieving those reductions or making up for any reductions not achieved. For this reason, EPA-verified numbers are conservative.

⁶ This calculation assumes the New Haven school buses, 93% of which are model year 2002, will operate for 4.5 years while retrofitted (from the middle of 2005 until the end of 2009).

1. INTRODUCTION

This report summarizes the results of a project to equip the First Student school bus fleet in New Haven, Connecticut, with emission control technologies. The project, which began in 2004, set a goal of retrofitting 181 conventional, front-engine diesel school buses with pollution controls to achieve the greatest possible long-term reduction in particulate matter (PM), hydrocarbon (HC), and carbon monoxide (CO). The retrofit project is part of the Connecticut Department of Environmental Protection's (CT DEP) *Clean School Bus Program*.

The need for reducing emissions from heavy-duty diesel engines, and from diesel school buses in particular, is clear. Current inventories estimate that emissions from heavy-duty diesel engines comprise 34 percent of all nitrogen oxides (NO_x) pollution, 43 percent of PM₁₀, and 56 percent of fine particulate matter (PM_{2.5}) from on-road sources in the Northeast states.⁷ Diesel exhaust poses a significant risk to human health, as it contains more than 40 chemicals listed as Hazardous Air Pollutants under the Clean Air Act and was recently classified as the sixth most potent carcinogenic substance reviewed by California's Scientific Review Panel.⁸ The HC and NO_x emissions in diesel exhaust are ozone precursors that contain known carcinogens and that can also exacerbate cardiopulmonary diseases. The PM_{2.5} in diesel emissions is known to aggravate respiratory illnesses such as asthma, emphysema, and bronchitis and is also linked to lung cancer. Children are especially susceptible to the risks associated with diesel emissions, because their immune and respiratory systems are still developing and they breathe up to 50 percent more air per pound of body weight than adults. For these reasons, the *New England Journal of Medicine* reports that exposure to air pollution may cause chronic decreases in lung function by age 18.⁹

Children riding on diesel school buses are exposed to elevated levels of harmful emissions. Recent studies have documented high levels of PM_{2.5} and other toxins in school bus cabins.¹⁰ In Connecticut nearly 387,000 children ride approximately 6,500 school buses each day, and 90 percent of those buses run on diesel fuel. While more stringent emissions standards for newly manufactured diesel engines will go into effect in 2007, older high-emitting diesels will be on the road for many years. Reducing children's exposure to diesel pollution therefore requires a strategy for those older bus engines,

⁷ Source: Mid-Atlantic/Northeast Visibility Union (MANE-VU) RPO 2002 Emissions Inventory, Version 2 E1; <http://www.marama.org/visibility/Inventory%20Summary/2002EmissionsInventory.htm>.

⁸ State of California, "Findings of the Scientific Review Panel on The Report on Diesel Exhaust," April 22, 1999; cited in Environment & Human Health, Inc., "Children's Exposure to Diesel Exhaust on School Buses," 2002.

⁹ W.J. Gauderman, et al., "The Effect of Air Pollution on Lung Development from 10 to 18 Years of Age," *New England Journal of Medicine* 351(11), Sept. 9, 2004, and a related study of truck density and "black smoke" inside schools: B. Brunekreef, et al., "Air Pollution from Truck Traffic and Lung Function in Children Living Near Motorways," *Epidemiology* 8(#):298-303. Both cited in New Jersey Department of Environmental Protection, "Gasping for Breath?" brochure.

¹⁰ Clean Air Task Force, "CATF School Bus Particulate Matter Study," 2005; and California Air Resources Board, "Children's School Bus Exposure Study," 2003.

including retrofitting them with advanced pollution controls and establishing and enforcing anti-idling programs.

The *New Haven School Bus Retrofit Project* was undertaken by CT DEP in conjunction with the New Haven Board of Education, City of New Haven, and U.S. Environmental Protection Agency (EPA). First Student, Inc. and the Connecticut Department of Motor Vehicles (DMV) also contributed to the project's success. Northeast States for Coordinated Air Use Management (NESCAUM) was hired by CT DEP to manage the project. All 181 buses included in the project are owned and operated by First Student, Inc., which has a contract with the New Haven Board of Education to transport children to and from elementary, middle, and parochial schools in the city. Funding for the project came from supplemental environmental project (SEP) funds.

This project dovetails with other efforts in Connecticut to reduce children's exposure to diesel pollution, such as CT DEP's agreement with the Connecticut School Transportation Association to eliminate unnecessary school bus idling. The agreement states that drivers will shut off school buses immediately upon reaching their destinations.

There were six components to the *New Haven School Bus Retrofit Project*: 1) fleet survey; 2) exhaust temperature data logging; 3) selection of emission control technology; 4) technology installation; 5) estimate of emissions reductions; and 6) education and media outreach. The report provides background and results in each area.

2. FLEET SURVEY

As a first step, First Student compiled an inventory of its New Haven fleet in Fall 2003 and provided information about the vehicles, engines, and fuel (see Table 1, below). The fleet is relatively new: 93 percent of the fleet was model year 2002 and 7 percent was manufactured in 2000 and 2001. From the standpoint of engine age, the buses were good candidates for diesel particulate filters (DPFs), which offer the highest level of particulate control. The chassis and engine configuration also made them good candidates for retrofit with closed crankcase ventilation (CCV) systems. Finally, the entire fleet uses ultra-low sulfur diesel fuel (ULSD) with sulfur levels specified to a maximum of 30 parts per million (ppm) by weight; in-use sampling yielded levels between 15 and 20 ppm. The fuel specifications were consistent with requirements for particulate filters. All other fuel properties are consistent with conventional, on-highway number two diesel fuel.

Table 1: Characteristics of First Student School Bus Fleet

Total No. of Buses in Fleet	181
School Bus Chassis/Body	
Bus Manufacturer	International Truck and Engine Corp., Inc.
Type	“C” – Front Engine Conventional
Model Year	2000 – 2002
Entry into Service	<ul style="list-style-type: none"> • 2000 – 10 buses • 2001 – 2 buses • 2002 – 169 buses
Expected Service Life	7 years
Average Annual Mileage	13,500 miles/bus
School Bus Engine	
Engine Manufacturer	International Truck and Engine Corp., Inc.
Engine Model	International T444E
Engine Configuration	OHV V-8
Engine Displacement	444 CID (7.27 L)
Engine Specification	<ul style="list-style-type: none"> • 195 HP @ 2300 RPM • 520 lb-ft Torque @ 1400 RPM • 2600 Max Governed RPM • Turbocharged & Aftercooled • Electronically Controlled FIE

3. EXHAUST TEMPERATURE DATA LOGGING

In late 2003 and early 2004, NESCAUM collected data on engine gas exhaust temperatures for three First Student buses to determine if they could be retrofitted with DPFs. To ensure data quality, the buses operated on their normal four-hour routes over several runs. The routes and driving conditions also varied to encompass best- and worst-case operating scenarios, with “best case” characterized by a sustained higher speed and “worst case” by a slower engine speed and extensive stop-and-go and idling.

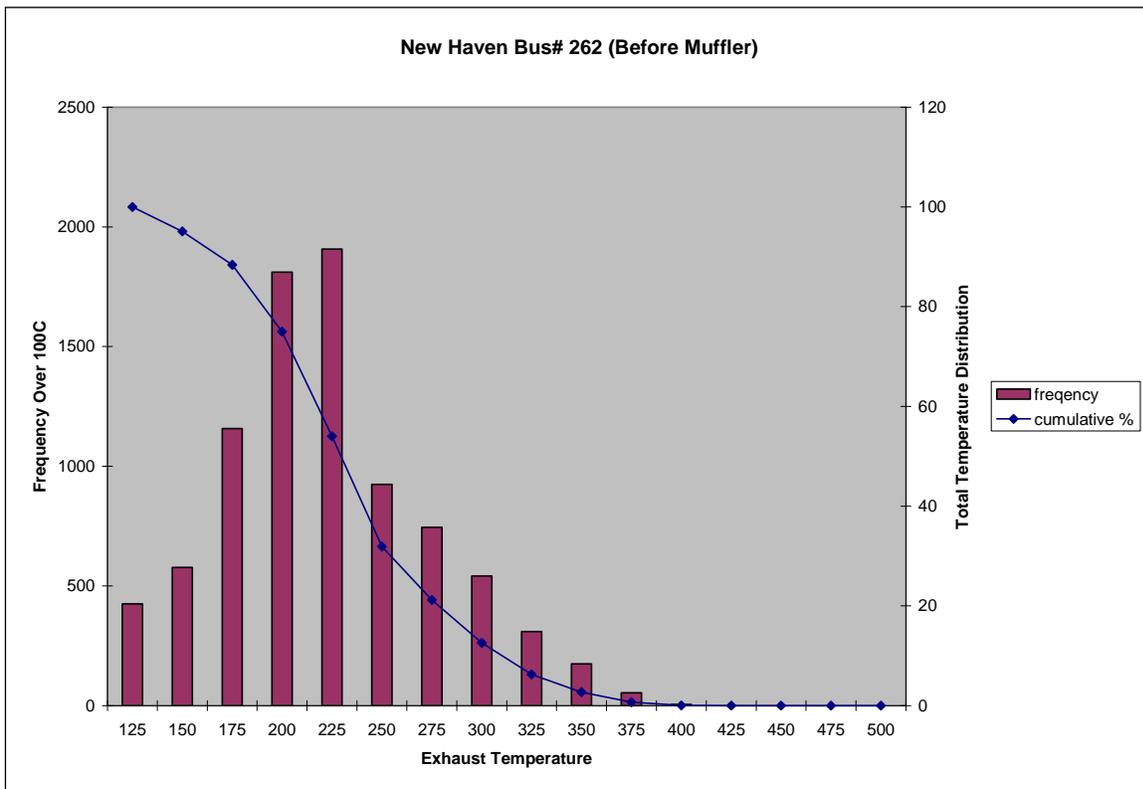
The first round of testing, over four-day¹¹ periods in November and December 2003 and January 2004, employed two representative buses from the First Student fleet. The buses were equipped with technology that measures the temperature in the exhaust stream before it enters the muffler. A thermocouple welded to the exhaust pipe was attached to a recording device known as a data logger; measurements were taken every 10 seconds during the test runs.

¹¹ Data were collected over 3 days and 16 hours.

The project team decided that the first round was not sufficiently robust, so a second round of testing occurred over four days in March 2004. Three buses, including the two used in the first round (numbers 262 and 127), were outfitted with two standard Hobo-Boxcar, “off-the-shelf” data loggers and conventional type-K thermocouples, which were located laterally approximately six inches upstream of the inlet to the vehicle muffler, and radially in the approximate center of the exhaust stream, about six inches after the inlet to the turbo flow. One bus (number 262) operated in a “best case” duty cycle; the other two (numbers 127 and 270) in “worst case” scenarios.

Figure 1 below shows the “best case” exhaust temperature scenario with the bus making relatively infrequent stops and idling for only short periods. This bus was driven for 3.5 hours in both the morning and afternoon. The run included 45 minutes on the highway and substantial travel in rural and suburban areas. The bus made 12 stops in the suburbs and 5 in more rural areas.

Figure 1: School Bus #262 Temperature Data Logging Results

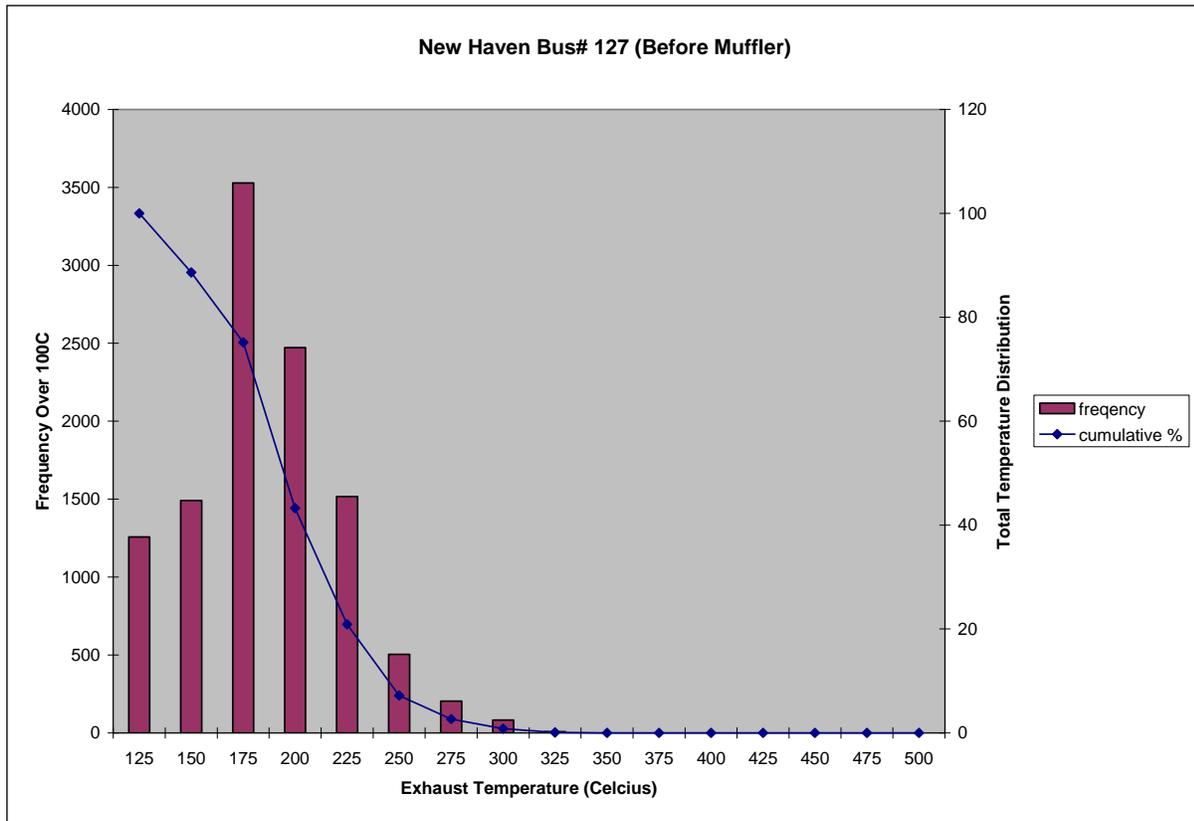


As the bars indicate, most of the time the bus operated with exhaust temperatures in the range of 200-225 degrees Celsius, with substantial time at 175 degrees as well. The critical information is that exhaust temperatures were above 240 degrees for only approximately 30 percent of the duty cycle.

Data collected from a bus operating in the “worst case” duty cycle (Figure 2 below) showed even lower exhaust temperatures. Bus #127 ran in the city for 4 hours in both the morning and afternoon and made frequent short stops. The duty cycle had minimal highway driving. Exhaust temperature was most often 175 degrees and exceeded 240 degrees approximately 15 percent of the time. The third bus (#270) had a similar profile.

Exhaust gas temperatures below 240 degrees Celsius for significant periods are too low for successful use of DPFs. To ensure effective regeneration and prevent plugging, the exhaust gas temperature should be above 240 degrees Celsius for at least 60 percent of the duty cycle. If DPFs were installed on engines with low exhaust gas temperatures, they would require frequent cleaning or manual “off-vehicle” regeneration by First Student’s service technicians. The results of the data logging excluded passive particulate filters as an option for the retrofit project in New Haven.

Figure 2: School Bus #127 Temperature Data Logging Results



4. SELECTION OF EMISSION CONTROL TECHNOLOGY

The project team established a Selection Committee to develop criteria for and to select control technology that would maximize emissions reductions fleet-wide. The Committee included stakeholders with expertise in diesel emissions, environmental public policy, fleet management and operations, pupil transportation, and government and regulatory policy. Participants included staff from CT DEP, New Haven Department of City Planning, New Haven Board of Education, First Student, Inc., EPA Region 1, and NESCAUM.¹²

The Committee's initial goal was to choose a technology that would most effectively reduce emissions of PM within the available budget for the project. Discussions focused on a number of commercially available DPFs, which would be used to retrofit as many of the 181 buses as possible. When NESCAUM's data logging ruled out using DPFs, the Committee's attention turned to two issues: reducing tailpipe emissions effectively without technologies that need high exhaust gas temperatures; and reducing in-cabin pollution from the crankcase emissions typical of the turbocharged front engines used in the First Student fleet. The Committee also placed considerable emphasis on attaining the maximum emissions fleet-wide by increasing the number of retrofitted vehicles. In addition, although the SEP did not require technologies verified by either EPA or the California Air Resources Board, the Selection Committee felt strongly that verified products offer both the data necessary to calculate estimated fleet-wide emission reductions and some assurance of product durability.

In May 2004 NESCAUM issued an RFP with a detailed set of criteria, including capabilities in the areas of technical management, emission control technology (ECT) pilot programs, ECT technical merit and feasibility, ECT environmental benefits, project support, training, timetable for delivery, budget, and affirmative action (see Appendix 4). Five companies submitted proposals, and after extensive review (see Table 2), the Committee selected two vendors: Donaldson Company, Inc. to supply a combination of its 6100 series diesel oxidation catalyst (DOC) and its Spiracle closed crankcase ventilation (CCV) system for all 181 buses; and Clean Diesel Technologies, Inc. (CDTI) to dose the entire fleet (including an additional 69 Type A vehicles) with its Platinum Plus fuel-borne catalyst. The Donaldson system is a well-proven, EPA-verified technology; and the per-vehicle cost of \$1,350 would allow retrofitting of all 181 buses. The combination of the DOC and CCV would also yield the highest fleet-wide emissions reductions. The CDTI fuel-borne catalyst used with a DOC is EPA registered and verified as well and offers both enhanced emissions reductions and improved fuel economy.

The estimated cost of the CDTI additive was \$6,825 for the dosing unit, including installation, and \$26,775 annually for the fuel-borne catalyst, based on an estimated use of 535,000 gallons treated at 1:1500. Replacement intervals for the Spiracle filters are vehicle and duty-cycle specific, but estimated at once a year for each bus, at a cost of \$40 per replacement filter or \$7,240 per year for all 181 buses.

¹² For a complete discussion of the selection process, see NESCAUM, "Vendor Recommendation: New Haven School Bus Retrofit Project," November 5, 2004.

Table 2: Selection Committee’s Vendor Comparison

Vendor	Technology	“The Positive”	“The Negative”	EPA/AR B Verified?	Selected for Project?
CDTI	FBC+DOC	<ul style="list-style-type: none"> • Significant PM reductions (EPA verified 25–50%). • No EGT dependency. • CT-based company. • A number of ongoing truck fleet retrofits (Coca-Cola). • Verified technology facilitates quantifying emission reduction benefits. 	<ul style="list-style-type: none"> • Concern about potential health risks from platinum emissions. • Mechanics of adding FBC to the fuel stream. • No school bus applications yet (Stamford in 2004). 	Yes	Yes
Donaldson	CCV + DOC	<ul style="list-style-type: none"> • Only CCV system (Spiracle[®]) commercially available. • No EGT dependency. • Large, well-established company with significant product success track-record. • Local distributor involved in proposal process; indicates commitment during installation and service of ECTs. • Numerous prior applications, including school buses (NYSERDA). • Costs consistent with project ECT budget, ensuring full-fleet retrofit. • Verified technology facilitates quantifying emission reduction benefits. 	<ul style="list-style-type: none"> • Modest tailpipe PM reductions via DOC. • Concerns about product availability. 	Yes	Yes
ECS	DOC	<ul style="list-style-type: none"> • Conventional DOC technology well-proven in field retrofits. • No EGT dependency. 	<ul style="list-style-type: none"> • Minimal PM reductions (≈20%); offer only conventional DOC. • Canadian company with few US-based dealers to provide installation and support. 	Yes	No
ESW	DOC (Clean Cat [®]) & DPF (Particulate Reactor [™])	<ul style="list-style-type: none"> • DOC not EGT dependent. • DPF is EGT dependent, but ESW data indicates feasible application for New Haven. • Substantial PM reductions with DPF (≈50-70%). 	<ul style="list-style-type: none"> • DOC is conventional technology with modest PM reductions. • DPF is cost prohibitive for full-fleet retrofit. • Neither ARB nor EPA verified. 	No	No
FES	OCV+DOC	<ul style="list-style-type: none"> • Good relationship on other NESCAUM and CT projects. • Local company. • Well-proven product. • OCV system another approach to reduce crankcase emissions. • OCV & DOC not EGT dependent. 	<ul style="list-style-type: none"> • Modest PM reductions: DOC is conventional (≈20%), while OCV is significantly less effective than Spiracle[®] CCV, at similar cost. • OCV not verified. 	OCV, No; DOC, Yes	No

5. INSTALLATION OF TECHNOLOGY

First Student agreed to install all 181 of the Donaldson Spiracle CCV plus DOC combinations, while Clean Diesel Technologies was responsible for designing and installing the dosing unit. Donaldson provided training at no charge and worked with First Student on design solutions to ensure a proper fit on the New Haven buses. This included retooling the DOC, reconfiguring and cutting the exhaust pipe, and reengineering the support bracket for the Spiracle so that it could fit on the left front of the cylinder head of the engine, instead of hanging from the radiator.

5.1. Training

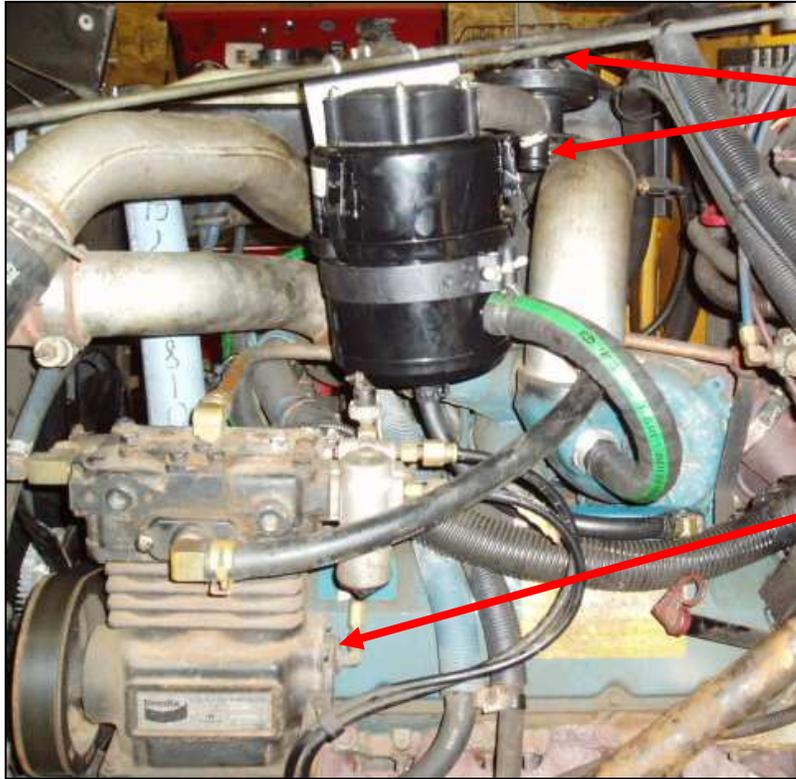
In September 2004 Donaldson sent a field engineer to First Student in New Haven to conduct a one-day workshop for maintenance staff and the project team on the installation of its Spiracle + DOC system. The engineer detailed Donaldson's product warranty and technical support services, distributed installation manuals, and conducted a step-by-step installation of the system. Participants noted that the instruction manuals covered installation on a transit-style school bus rather than the conventional front-engine buses in the First Student fleet; the Donaldson engineer promised to address this concern by updating the manuals for multiple bus types.

5.2. Installation Challenges: Donaldson Spiracle CCV and DOC

Both the Spiracle CCV and the DOC presented installation challenges. NESCAUM, First Student, and CT DMV all felt that the proposed Spiracle mounting design, although used in other school bus applications, was too unstable to be approved for this project. For the DOC, Donaldson provided a somewhat generic mounting kit, which required significant modification to the engine exhaust pipe. Considerable efforts, spearheaded by First Student, were necessary for successful installation of both the CCV and DOC. For example, the first Donaldson estimate of 1.5 hours to install the DOC was unrealistic with the kit provided; First Student's initial attempt at a successful installation required nearly 4.5 hours.

5.2.1. Spiracle CCV Installation

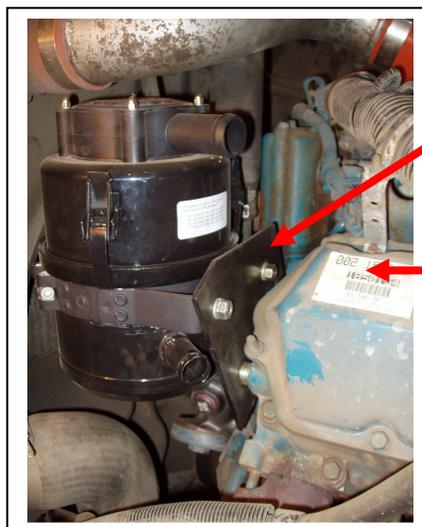
As noted above, Donaldson's design for mounting the Spiracle in the engine compartment of the school bus was judged too unstable. The design specified suspending the Spiracle between the threaded support stanchions that are used to support the engine's radiator, as shown below:



Spiracle mount on radiator stanchions (initial design)

Air Compressor

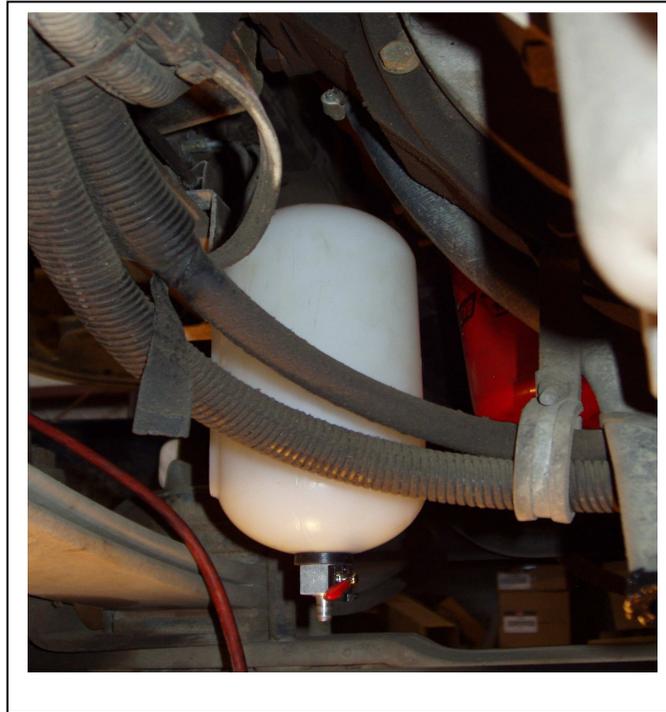
Donaldson devised this approach in response to space limitations in the engine compartment arising from the requirement, in many school buses of this type, for an air compressor for an air-assisted braking system. However, no buses in the First Student fleet use air-assisted brakes. First Student's shop manager recognized an opportunity to install the Spiracle in the space normally reserved for the air compressor and designed a revised mounting bracket that directly attaches the unit to the left side (driver's side) cylinder head of the engine, as shown below:



New mounting bracket

Left front of engine cylinder head

The final revision in the Spiracle installation was to provide a catch bottle for oil vapors that precipitate from the unit and are not recirculated through the engine's induction system. Normally, a fitting on the lower edge of the engine's crankcase allows for direct routing of the oil hose from the Spiracle. However, since none of the First Student buses have this crankcase fitting, installation of the remote-mounted oil catch bottle was necessary. Donaldson provided the bottle; emptying of any oil in the bottle coincides with normal engine oil change intervals. Final installation of the bottle is shown below:



Donaldson covered the cost of the hardware for this revised Spiracle installation, including:

- New steel mounting plates.
- Steel spacers (between the plate and engine cylinder head) – 3 per bus.
- Oil drain bottle mounting brackets.
- Hoses connecting the Spiracles and oil drain bottles.

5.2.2. DOC Installation

Difficulties in the installation of the DOC arose from having a generic installation kit that required considerable modification for the engines in the First Student buses. Specifically, the engine exhaust pipe is 3 ¾" outer diameter (OD), while the DOC uses a 4" inner diameter (ID). To effectively attach these two, Donaldson's generic kit supplies an intermediate "transition pipe." Installing this pipe on the First Student buses, however, required cutting the exhaust system and maneuvering the DOC into the proper position between the frame rails of the school bus – a procedure that was both onerous and time-consuming. As a solution, Donaldson agreed to re-tool the ID of the DOC so

that it would align with the OD of the engine exhaust pipe, eliminating both the transition pipe and the cutting of the exhaust pipe. Delivery of these revised DOCs delayed installation, but Donaldson assumed all costs for the re-design.¹³

5.3. Installation Challenges: CDTI Platinum Plus FBC

After considering a pilot project to use CDTI's Platinum Plus fuel-borne catalyst with a DOC on 10 buses, the project team agreed to dose all 181 Type C buses, plus another 69 Type A buses, with the additive. CDTI installed a Hammonds ITHO700 Automatic Dosing System with a 35-gallon reservoir.

Platinum Plus, used with a DOC, is an EPA registered and verified fuel additive. The registration process is intended to screen out any fuel additives that could cause adverse health impacts from increased air pollution emissions.

A month after the dosing began, the team decided to discontinue use of the fuel-borne catalyst due to concerns about potential health risks posed by the platinum concentration in it. The scientific literature has data only on the health impacts associated with large doses of platinum in emissions. The lack of information about exposure to small doses prompted the team to take a conservative approach and to discontinue the dosing part of the retrofit program.

6. ESTIMATED EMISSIONS REDUCTIONS

The Donaldson Spiracle + DOC is an EPA-verified technology rated to attain up to a 28 percent reduction in combined tailpipe and crankcase PM emissions. The EPA verification program provides conservative estimates of emissions reductions;¹⁴ anticipated reductions in New Haven are 32 percent PM, 42 percent HC, and 34 percent CO. The estimated annual reduction for the fleet is 471 lbs/yr of PM, 8018 lbs/yr of HC, and 77,359 lbs/yr of CO. The anticipated service life of these buses is approximately 7 years; over the life of the fleet, therefore, the project will reduce 1 ton of PM, 18 tons of HC, and 174 tons of CO from the New Haven school bus fleet.¹⁵

¹³ To date, 120 buses have been retrofitted, and the remaining 61 buses will be retrofitted by March 2006. While the entire fleet was scheduled to be retrofitted by the summer of 2005, staff shortages at First Student considerably slowed the installation.

¹⁴ The EPA verification process is intended to establish SIP creditable emission reductions (states can claim up to 3 percent of needed SIP credits through voluntary programs), which makes states responsible for achieving those reductions or making up for any reductions not achieved. For this reason, EPA-verified numbers are conservative.

¹⁵ This calculation assumes the New Haven school buses, 93% of which are model year 2002, will operate for 4.5 years while retrofitted (from the middle of 2005 until the end of 2009).

Table 3: Estimated Emissions Reductions from Spiracle + DOC

	HC (lbs/yr)	CO (lbs/yr)	NOx (lbs/yr)	PM (lbs/yr)
Uncontrolled emissions	105.4	1,257.0	324.4	8.1
Controlled emissions (Spiracle + DOC)	61.1	829.6	324.4	5.5
Quantity reduced annually/vehicle	44.3	427.4	0.0	2.6
Quantity of vehicles	181			
Emissions reductions for all 181 buses	8,018.3	77,359.4	0	470.6

Had the project continued using the CDTI fuel-borne catalyst, PM reductions may have increased by approximately 8 percent, HC by 3 percent, and CO by 6 percent.

7. EDUCATION AND MEDIA OUTREACH

There were two primary education and media outreach activities. The first was a workshop for the project team in which vendors of emission control technology described their products. The second was a press conference launching the retrofit project and featuring an air-quality curriculum for middle school students that was developed by CT DEP.

7.1. Vendor Workshop

To help the project team learn more about the available pollution control technologies for school buses, NESCAUM organized a vendor workshop on February 25, 2004, at the Kellogg Environmental Center in Derby, Connecticut (see agenda in Appendix 3). The workshop began with CT DEP giving an overview of the *New Haven School Bus Retrofit Project* and information about how the successful school bus retrofit project in Norwich provided a blueprint for the project in New Haven. Representatives from nine companies (Donaldson Company, Sprague Energy, Fleetguard, International, Emissions Solutions Worldwide, STT EMTEC, Engine Control Systems, O2 Diesel, and Clean Diesel Technologies) each gave ten-minute presentations on their technology, including requirements such as exhaust temperatures, emissions benefit, durability and longevity, required maintenance, company support, and cost. Following each presentation, there was a five-minute question-and-answer period for the workshop participants. The workshop helped the project team understand the technical options and informed the technology selection process.

7.2. Press Conference Launching the Project

On September 14, 2004, CT DEP and NESCAUM hosted a press conference at a New Haven middle school to formally announce the launch of the school bus retrofit project. The event resulted in positive coverage by both print and television media.

NESCAUM assisted CT DEP in developing a press release and fact sheet and also arranged for Donaldson Company and Clean Diesel Technologies to set up displays of their technologies for the media and public. CT DEP also featured an online educational curriculum designed to teach middle school students about air quality. The *Connecticut Clean Air Curriculum* will also use the New Haven school bus project as a case study. With \$99,000 in funding from EPA, CT DEP will work with science teachers in New Haven to incorporate the air quality curriculum into their lessons.

8. CONCLUSIONS

The *New Haven School Bus Retrofit Project* demonstrates that significant emissions reductions can be achieved through the use of commercially available, verified retrofit technologies. Over the life of the retrofitted buses (assumed to be until 2009 for the 2002 model year buses) the retrofit project will reduce 18 tons of HC, 174 tons of CO, and 1 ton of PM from the New Haven school bus fleet. The project also demonstrates that the maintenance staff of school bus operating companies, such as First Student, can install and maintain retrofit technologies on large fleets. Important to the success of the project was a locally based partnership approach, which engaged stakeholders in a serious evaluation of the best way to achieve emissions reductions that benefit not only the children who ride the school buses, but also the entire community. The partnership approach also helps build a local base of expertise, ensures completion of the installation, and creates investment in sustaining the benefits through maintenance and outreach.

The project also highlights the need for more information on exposure to particulate matter and other toxins on board school buses, both before and after retrofitting. In particular, data specific to the reductions achieved with the Spiracle closed crankcase ventilation system are needed. While initial data show significant reductions, more data will allow for increased SIP credits through the EPA Voluntary Retrofit Program and thus will provide other districts with incentives to use this technology. That in turn will bring more CCV systems to the market and lower the price.

Finally, the project indicates the need for a study of the potential health risks from exposure to small doses of platinum, so that emission reduction projects can safely and with confidence take advantage of such technologies as fuel-borne catalysts.

Appendix 1

Project Participants

Connecticut Department of Environmental Protection

Tracy Babbidge
Paul Farrell
Ariel Garcia
Sharon Gustave

Connecticut Department of Motor Vehicles

John Mrozowski
David Maestrini

City of New Haven

Mike Piscatelli
Madeleine Weil

New Haven Board of Education

Teddi Barra

First Student, Inc.

Steve Chagnon
Stacy Bobzean
Doug Eddy

U.S. Environmental Protection Agency, Region 1

Lucy Edmondson
Christine Sansevero

NESCAUM

Michael Block
Alycia Gilde

Appendix 2

Estimated Emissions Reductions from Spiracle CCV + DOC

Calculation Assumptions and Parameters			
Typical Rate of Fuel Consumption/Vehicle:	1.911	gal/hr	
Hours of Operation/Year:	1100	hours	
Typical HHD Brake Specific Fuel Consumption:	0.4	lb/bhp-hr	
Weight of #2 Diesel Fuel	7	lb/gal	
grams/lb	453.6	grams	

Calculated Values for Emissions Quantification			
Calculated Value for typical operating HP/vehicle	1.911 gal/hr	X	7 lb/gal #2 =
		0.4	lb/bhp-hr
			33.4425 hp/vehicle
Calculated Value for Fuel Consumption/vehicle/Year	1.911 gal/hr	X	1100 hours/yr =
			2102.1 gal/yr

HDD Emissions Standards, 1998 & Newer, g/bhp-hr

HC	CO	NOx	PM
1.30	15.50	4.00	0.10

EPA Verified percent Reduction for Technology

	HC	CO	NOx	PM
Spiracle + DOC	42percent	34percent	0percent	32percent

Calculated Annual Emissions / Truck (lb/yr)

	HC	CO	NOx	PM
Uncontrolled Emissions	105.4	1257.0	324.4	8.1

Controlled Emissions using Spiracle + DOC	61.1	829.6	324.4	5.5
Quantity Reduced Annually/vehicle	44.3	427.4	0.0	2.6

Quantity of Vehicles 181

Emissions Reductions, lb/yr

	HC	CO	NOx	PM
<i>Total Quantity Reduced Annually Using Spiracle + DOC</i>	8018	77,359	0	471

Appendix 3

Connecticut School Bus Retrofit Project Retrofit Technology Informational Meeting

**February 25, 2004
Kellogg Environmental Center, Derby, Connecticut**

Program Agenda

8:30 – 9:00 A.M. Registration and Continental Breakfast (30 minutes)

9:00 – 9:10 A.M. Welcome and Opening Remarks (10 minutes)
Alycia Gilde – NESCAUM

9:10 – 9:30 A.M. Project Background on Connecticut School Bus Retrofit Project (20 minutes)
Tracy Babbidge – CTDEP
Dave Park – NESCAUM

EPA Verified Retrofit Technology Presentations

9:30 – 9:40 A.M. *Clean Diesel Technologies* (10 minutes)

9:40 – 9:50 A.M. Question and Answers (10 minutes)

9:50 – 10:00 A.M. *Cummins Metropower Presentation* (10 minutes)

10:00 – 10:10 A.M. Questions and Answers (10 minutes)

10:10 – 10:20 A.M. *Donaldson Company* (10 minutes)

10:20 – 10:30 A.M. Questions and Answers (10 minutes)

10:30 – 10:40 A.M. *Lubrizol Corporation* (10 minutes)

10:40 – 10:50 A.M. Questions and Answers (10 minutes)

10:50 – 11:00 A.M. *International Truck and Engine Corporation* (10 minutes)

11:00 – 11:10 A.M. Questions and Answers (10 minutes)

11:10 – 11:20 A.M. *Sprague Energy Presentation* (10 minutes)

11:20 – 11:30 A.M. Question and Answers (10 minutes)

11:30– 11:40 A.M. - Morning Break (10 minutes) -

Non – EPA Verified Retrofit Technology Presentations

11:40 – 11:50 A.M. *Engine Control Systems Presentation* (10 minutes)

11:50 – 12:00 A.M. *ESW Canada Incorporation Presentation* (10 minutes)

12:00 – 12:10 A.M. *Infineum* (10 minutes)

12:10 – 12:20 P.M. O2 Diesel (10 minutes)
12:20 – 12:30 P.M. *RYPOS Incorporation Presentation* (10 minutes)
12:30 – 12:40 P.M. *STT EMTEC Presentation* (10 minutes)
12:40 – 1:40 P.M. - Lunch (1 hour) -
Introduce yourself to someone you don't know!

Moving Forward

1:40 – 3:40 P.M. Vendor Displays (1 hour and 15 minutes)
One to one interactions with vendors and their retrofit technologies.

3:40 – 4:00 P.M. Wrap Up and Closing Remarks (20 minutes)
Alycia Gilde – NESCAUM
Michael Block - NESCAUM

Appendix 4

Northeast States for Coordinated Air Use Management (NESCAUM)

Request for Proposals

New Haven, Connecticut School Bus Retrofit Project

May 19, 2004

Proposal Due Date: Wednesday, June 2, 2004, 4:00 p.m. EDT

Notification Date: Friday, June 11, 2004

Initial Project Planning Meeting Date: Week of June 14th, 2004

*Project Contact: Michael Block, NESCAUM
(617) 367-8540 x 218; mblock@nescaum.org*

Table of Contents

I. Overview

II. Project Description

- A. Goals
- B. Scope of Work
- C. Fleet Information
- D. Engine Exhaust Gas Temperature Profiles

III. Responding To The RFP – Inclusions For Submission

- A. Proposal Summary
- B. Project Management Capabilities
- C. Company Overview
- D. ECT Selection Methodology
- E. Description of Candidate ECT
- F. ECT Pilot Program
- G. Technical Familiarity with Targeted School Bus Fleet
- H. Quantifying Emission Reductions
- I. Product Delivery
- J. Product Installation
- K. Training
- L. In-Use Service and Support
- M. Budget

IV. Selection Committee

V. Evaluation Criteria For Selection

- A. Technical Management
- B. ECT Pilot Program
- C. ECT Technical Merit and Feasibility
- D. ECT Environmental Benefits
- E. Project Support
- F. Training
- G. Timetable for Delivery of Product
- H. Budget
- I. Affirmative Action

VI. NESCAUM Terms And Conditions

- A. NESCAUM Terms and Conditions
- B. Vendor Response

I. Overview

The Northeast States for Coordinated Air Use Management (NESCAUM) is a non-profit association of the air quality control agencies in the six New England States, New York and New Jersey. NESCAUM provides technical assistance and policy guidance to the member states on air pollution issues of regional concern. NESCAUM has been actively engaged in the development and implementation of a wide variety of emission reduction projects for highway and nonroad vehicles. Through this request for proposal (RFP), we are seeking a qualified company to select and provide emission control technology (ECT) to reduce diesel particulate matter (PM) from a targeted fleet of diesel-powered school buses in the City of New Haven, CT. This project involves procuring, installing and supporting ECTs for a fleet of 182 type “C”, full size school buses operating in New Haven. The ECTs will be installed on this fleet from mid-June through mid-August 2004, while school is in summer recess.

The goal of the project is to achieve maximum, sustainable, PM, HC and CO emission reductions for the New Haven school bus fleet.

The entire fleet is owned and operated by First Student, Inc., under contract to the City of New Haven, and all buses are housed, fueled and maintained at First Student’s central facility in New Haven. The entire fleet operates using ultra-low sulfur diesel fuel (ULSD) with sulfur levels specified to a maximum of 30 parts per million (ppm) by weight; in-use sampling has yielded levels between 15 and 20 ppm. All other fuel properties are consistent with conventional, on-highway number two diesel fuel.

NESCAUM has completed an analysis of engine exhaust gas temperatures from selected school buses in the fleet. That profile, explained in further detail below, shows temperatures on average, below 250°C for a significant portion of the daily, typical in-use operation (“duty-cycle”). Applicants should provide documentation of their review of these data as part of their technical assessment of the most appropriate ECT for this program.

Proposals will be judged by a Selection Committee, defined in section IV of the RFP, and evaluated by NESCAUM. Favorable consideration will be given to those submissions that clearly demonstrate an ability to provide maximum PM emission reductions, *without compromising the safe, timely transportation of pupils during the school year*. In-kind contributions for this important, highly-viable program are encouraged.

Submissions to the RFP are due by 4:00 p.m. Eastern Daylight Time (EDT) Wednesday, June 2, 2004. Submission of **six hardcopies** of the proposal should be sent to the following address:

Michael Block
Senior Staff Engineer
Northeast States for Coordinated Air Use Management (NESCAUM)
101 Merrimac Street, 10th Floor
Boston, MA 02114
(617) 367-8540 x 218
mblock@nescaum.org

Electronic submissions are optional but encouraged.

NESCAUM will announce award notifications on Friday, June 11, 2004. A mandatory project planning meeting, at a venue in New Haven, will be scheduled for the week of June 14th, to formally initiate the program.

II. Project Description

A. Goals

1. Maximize reductions of PM, HC and CO, without the increase of any other pollutants, through installation of ECTs.
2. Provide sustainable support ensuring the effective operation of the ECTs for the full period of time (typically seven years) the school buses are in daily service in New Haven.
3. Provide full warranty coverage of the entire ECT system.
4. Ensure safe operational performance of the ECT system, the engine and the school bus, and adhere to the safety precepts of the Connecticut Dept of Motor Vehicles, Commercial Vehicle Safety Division.

B. Scope of Work

This project involves retrofitting the fleet of school buses operating in the City of New Haven, Connecticut, with emission control technology (ECT) designed primarily to maximize the reduction of diesel particulate matter (PM). Additionally, the technology should demonstrate proficiency in reducing hydrocarbons (HC) and carbon monoxide (CO). Generally, emission control technologies tailored to the reduction of these three constituents – specifically, diesel particulate filters (DPFs) and diesel oxidation catalysts (DOCs) – are ineffective for the reduction of oxides of nitrogen (NO_x). Nevertheless, significant PM-reductions may foster the potential use of NO_x mitigation strategies such as software modifications to the engine's electronic control unit (ECU). Prospective vendors should comment on engine and operations compatibility issues if NO_x-reduction approaches are considered in the proposal.

The fleet consists of 182 late model, low-mileage school buses. All are of the same configuration, manufactured by the same company (both bus chassis and engine), and owned and operated by a single company, under contract to the City of New Haven (refer to Section II.C, below). Working closely with NESCAUM, who will be responsible for overall project management and fund disbursement, the vendor will provide ECTs to meet the goals, stated above. In addition to supplying the ECT hardware, the contractor will be responsible for the following tasks: (1) complete systems engineering; (2) delivery and installation; (3) service technician and driver training; and (4) follow-up product and system support to sustain effective operation of the ECT throughout the time that school bus is in daily operation in the City of New Haven. Towards this end, the prospective vendor should provide a work plan describing how they will successfully implement, at a minimum, the following specific tasks:

1. Interfacing with engine and vehicle manufacturer to ensure ECT compatibility (includes obtaining a *mandatory* warranty letter from the engine manufacturer).
2. Procuring the ECT, including storage for “just-in-time” delivery to the installation job site.
3. Engineering, fabricating and procuring all installation hardware.
4. Developing and procuring in-use operating software such as exhaust backpressure and temperature monitoring systems, if appropriate.
5. Installing the complete ECT system, including the ECT and the hardware and, if applicable, software kits.
6. Developing a maintenance plan to ensure long-term effective ECT operation.
7. Training fleet service technicians in installation, maintenance, and “in-use” troubleshooting and safety.
8. Training fleet drivers in proper operation, detection of operating anomalies, and proper safety procedures.
9. Documenting retrofit installation through accurate recordkeeping as well as providing instruction manuals to service technicians and school bus drivers.
10. Participating in sustainability activities – Project Partners will be developing and implementing outreach and education programs associated with this project. Prospective vendors are expected to participate in these endeavors and are encouraged to provide details regarding the extent and type of their participation.

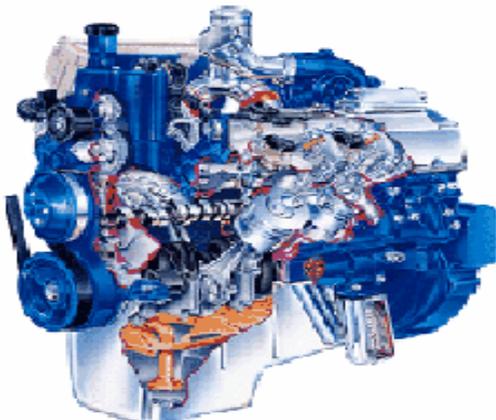
C. Fleet Information

The following table provides school bus fleet information for the First Student Fleet, which services the public schools in the City of New Haven. NESCAUM anticipates that the homogeneity of the fleet – school bus vendor,

chassis and engine type, fuel type and specification, common domicile, etc. – will encourage selection of a singular ECT type, fleetwide:

School Bus Chassis & Engine Description	School Bus Data	Fleet Owner & Operator
School Bus Chassis/Body		First Student, Inc. 140 Middletown Ave. New Haven, CT 06513
Total No. of Buses In Fleet	182	
Bus Manufacturer	International Truck and Engine Corp, Inc.	
Type	“C” – Front Engine Conventional	
Model Year	1999 – 2002	
Entry Into Service	<ul style="list-style-type: none"> • 1999 – 1 bus • 2000 – 10 buses • 2001 – 2 buses • 2002 – 169 buses 	
Typical Number of Years Buses Are Expected to Remain In Service	7	
Average Typical Yearly Mileage Per Bus	13,500 miles/bus/annum	
School Bus Engine		
Engine Manufacturer	International Truck and Engine Corp, Inc.	
Engine Model	International T444E	
Engine Configuration	OHV V-8	
Engine Displacement	444 CID (7.27 L)	
Engine Specification	<ul style="list-style-type: none"> • 195 HP @ 2300 RPM • 520 lb-ft Torque @ 1400 RPM • 2600 Max Governed RPM • Turbocharged & Aftercooled • Electronically Controlled FIE 	

Table 1 – Fleet Description



INTERNATIONAL T444E OHV V-8

International Type “C” School Bus

D. Engine Exhaust Gas Temperature Profiles

NESCAUM has completed exhaust gas temperature characterization on two representative school buses in the First Student fleet, encompassing best and worst case in-use operating scenarios (commonly referred to as vehicle operation “duty-cycles”). Worst-to-best case designations are defined by the extremity of the duty-cycle: bus routes (duty-cycles) characterized by lighter engine speeds and loads are typified by extensive stop-and-go and idling periods, and are adjudged to be “worst case” scenarios. Similarly, best-case scenarios are characteristic of more sustained higher speed and load operation, often over more suburban and rural routes.

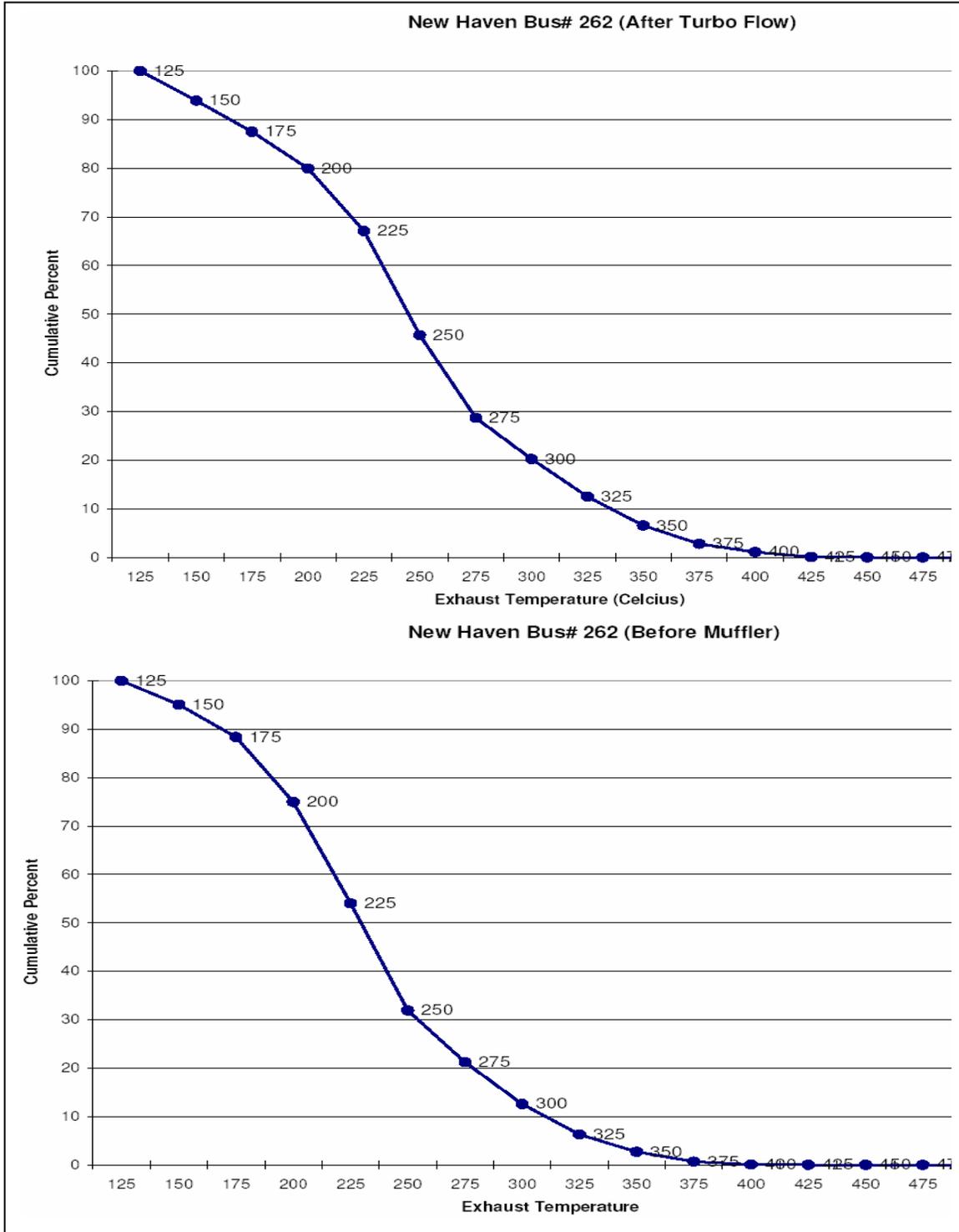
The data were collected on buses from the First Student fleet over daily, in-use operation, transporting students during the school season, in Mid-March 2004. Tested buses utilized their original-equipment installed mufflers, with no ECTs installed. Onset Computer Corporation Type K Thermocouple Dataloggers were utilized in conjunction with 1/8” diameter type-K thermocouple probes, which were installed in two locations in the exhaust system. One probe was located laterally approximately six inches upstream of the inlet to the vehicle muffler, and radially in the approximate center of the exhaust stream. A second probe was located laterally approximately one foot from the outlet of the engine turbocharger, also radially in the approximate center of the exhaust stream. Exhaust temperature data was collected at a frequency of eight seconds.

The data revealed exhaust gas temperatures that may be too low for successful implementation of certain ECTs, even for the “best case” bus number 262 (exhaust temperatures were higher, as expected, near the turbocharger outlet, than at the inlet to the muffler). For example, diminished engine exhaust gas temperatures may compromise the operation of some passive-design DPFs, impeding effective regeneration of entrapped PM. Operation in this manner would require frequent cleaning, or manual “off-vehicle” regeneration by First Student service technicians. *Applicants are encouraged to review the exhaust gas temperature data carefully, and may contact NESCAUM if further explanation of the results is required for submission of an effective proposal:*

School Bus No. 262 – Adjudged To Be “Best Case”

Test Dates: 16 – 18 March, 2004

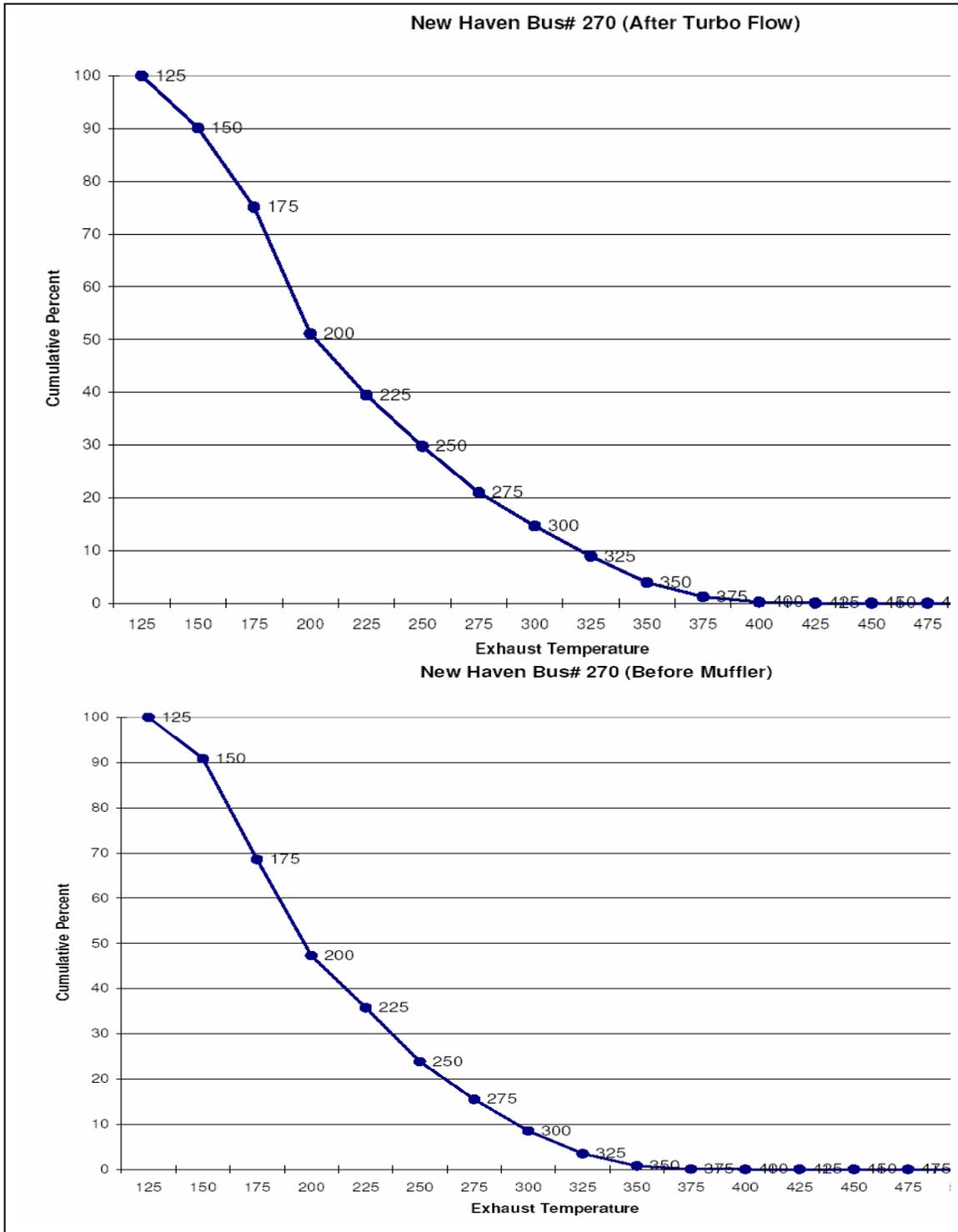
Duty-Cycle Description: Bus no. 262 travels on the highway for 45 minutes for a duration of 3.5 hours in the morning and a similar amount of time in the afternoon. The cycle is characterized by substantial travel in rural and suburban areas. A typical route includes approximately 12 stops in the city and five in the more rural and suburban areas.



School Bus No. 270 – adjudged to be “Worst Case”

Test Dates: 16 – 18 March, 2004

Duty-Cycle Description: Bus no. 270 operates in the city for four hours both in the morning and in the afternoon making short stops. The duty cycle is characterized by minimal highway travel.



III. Responding To The RFP – Inclusions For Submission

For complete consideration of the proposal, the respondent must adhere to the format and information requests specified in this section. It is imperative to respond to all parts of this section with sufficient detail, demonstrating an understanding of the technical and managerial precepts, and enumerated goals of this program.

A. Proposal Summary

Provide a proposal summary including an overview of the workplan with assumptions and deliverables, which will achieve the goals delineated in Section II.A. Briefly describe the company's track record and capabilities that would substantiate successful implementation of the selected ECT to ensure maximum PM, HC and CO emissions reductions, without the increase of any other pollutants.

B. Project Management Capabilities

NESCAUM is responsible for overall project management and coordination including disbursement of project funds. It is incumbent upon the prospective ECT vendor to demonstrate an ability to effectively interact with NESCAUM, in addition to procuring, installing and supporting selected emission control (retrofit) technology. The vendor must provide the following project management information:

1. Describe the project management team that would be deployed.
2. Provide the names and positions of key personnel within your organization that will lead the technical ECT operations.
3. List the management and administrative resources available to effectively perform project tasks and provide the project deliverables.
4. Provide examples of previous project experience relevant to the organization and installation of ECTs, *especially on school bus applications*.
5. Describe the project management approach in interacting with NESCAUM, First Student and other Project Team members.
6. Describe project management tools, including relevant software packages that would be deployed to ensure timely delivery and installation of the ECTs.
7. Outline the record-keeping methodology that would be utilized to ensure timely and well-documented ECT installation.

C. Company Overview

Provide an overview of the company, focusing on initiatives and specific project performance that substantiate proficiency in providing, implementing and

sustaining technology consistent with the goals of this program. Include a brief historical overview focusing on specific areas of expertise relevant to this project. Publicly-traded companies are *required* to provide year-end 2003 financial statements, and privately-held companies are strongly encouraged to provide evidence of financial solvency. Private financial disclosure will be treated as Confidential Business Information (CBI).

D. ECT Selection Methodology

Carefully explain the process used in selecting the specific ECT for this project. The narrative should include an evaluation of the engine exhaust gas temperatures described in section II.D, as well as any other in-use, “real-world” implementation issues that may compromise successful ECT deployment. Provide documentation outlining deployment of the selected ECT in similar applications. Emphasize ECT experience with similar school bus applications on past and/or current projects.

E. Description of Candidate ECT

In support of the selection strategy outlined in section III.D, the prospective vendor must provide a detailed description of the ECT selected for this project. The narrative should include, but not be limited to, inclusion of the following key information:

1. underlying operating principle of the ECT;
2. EPA and ARB verification status;
3. performance verification through other programs, such as VERT or DEEP, if applicable;
4. commercial availability;
5. Warranty coverage:
 - a) ECT itself – Detail the extent and limitation of the ECT warranty. How long is the warranty period? Does it cover parts and labor? How readily available are replacement parts? What service conditions are required to ensure the ECT warranty is not inadvertently voided?
 - b) School bus engine, other ancillary components – Describe the extent of warranty coverage in the event failure of the ECT precipitates the failure of an engine or vehicle component.
 - c) Warranty Letter – *the selected vendor **must** be able to provide a letter from International Truck and Engine Company, Inc. ensuring the installation of that vendor’s ECT will not in any way null, void, or otherwise impede the engine or vehicle warranty of International Truck and Engine, Inc.; and*

6. safety procedures for service technicians and school bus drivers.

F. ECT Pilot Program

A pilot program consisting of trial installation and in-use assessment of the ECT, on a small but representative number of school buses in the First Student fleet, is a *mandatory component* for this project. It will be the responsibility of the prospective vendor to develop and complete this program to the satisfaction of the project team, prior to proceeding with fleetwide ECT installation.

Carefully explain how this pilot program will be designed, initiated, and implemented. Sample guidelines that may be of assistance in responding to this section of the RFP include:

1. What is the overall timetable for the pilot program?
2. How many vehicles will be targeted for pilot retrofit?
3. Will the costs for the pilot program be included in the overall project budget, or will the vendor assume all or part of the costs to develop the pilot program, as means of demonstrating the efficacy of the selected ECT to the project team?
4. What length of time and/or vehicle miles is sufficient to have conclusively demonstrated the feasibility of the selected ECT?
5. The pilot program should replicate full fleet ECT installation and daily operation as closely as possible. Itemize and explain any installation or operational differences in the pilot program from the full fleet program, if any.

G. Technical Familiarity with Targeted School Bus Fleet

Section II.C provides information regarding the engines and school buses comprising the New Haven First Student Fleet. Provide a brief overview describing the company's technical familiarity and prior experience with the engine and bus chassis used for this fleet. Describe the company's interaction with International Truck and Engine Corporation, and/or International's distributors or dealers.

H. Quantifying Emission Reductions

This RFP requires the applicant to provide an estimate of PM, HC and CO emission reductions, without the increase of other pollutants, using the proposed ECT, for the school bus fleet described in section II.C. Contractually, there are no constraints regarding selection and subsequent deployment of ECTs verified under the US Environmental Protection Agency's Environmental Technology Verification (EPA ETV) program.¹⁶ However, candidate technologies that have

¹⁶ Information regarding the program is available at:
<http://www.epa.gov/otaq/retrofit/retrofittech.htm>

been verified under the EPA ETV program benefit from a publicly-accessible database of quantifiable emission reduction performance data for specific on-highway applications. As such, calculations of emission reductions, referencing the ETV emission data, are easily substantiated. The preference for this project would be the use of EPA verified technology.

Proposed technologies that have not been verified under the EPA ETV program are still eligible as candidate technologies for this project, but the vendor must provide a methodology for calculating and measuring, where appropriate, PM, HC and CO emission reductions, on both a fleetwide and “per bus” basis. Technology emission performance data may be gleaned from other verification programs such as those from ARB, VERT or Canada’s DEEP program, from the manufacturer’s own in-use testing¹⁷, or from an in-use testing strategy, specific to this program. If the latter approach is selected, applicants should provide a detailed outline describing the in-use, on-board vehicle emission data gathering methodology, the type of equipment used including manufacturer, and the data reduction techniques that would be employed.

I. Product Delivery

With the large number of school buses slated for retrofit under this program, timely product delivery is of paramount concern. It is highly probable that neither First Student nor NESCAUM will be able to stockpile large quantities of ECTs or attendant installation kits. In this section, the candidate vendor should detail their methodology for ensuring timely procurement of the proper quantities of ECTs and ECT installation kits. Analogous to “just-in-time” manufacturing processes, it is imperative that ECTs/ECT kits be available in small batch quantities, on an “as needed” basis, for installation either by the vendor, or First Student’s service technicians.

J. Product Installation

In this section the prospective vendor should outline the mechanism for timely installation of the ECT. The goal for this project is to complete the retrofits by August of this year, prior to the start of the school term. First Student has committed to providing support for the installation process. The installation approach proffered by the applicant may include installation by the vendor’s own dealer/distributor, by some third party expert, by First Student, or from a combination of these alternatives. *The installation plan described in this section should clearly delineate the division of task responsibilities for ECT installation.*

As part of the installation narrative, provide a detailed description of all hardware required for timely installation of the ECT. The hardware should be in

¹⁷ Data adjudged by the applicant to be proprietary and identified as “CBI”, may still be provided for this RFP, and will be regarded as “confidential.”

the form of a finalized, completed kit – designed, developed, fabricated and otherwise fully vetted – that is specific to the type, manufacturer and model year of the school bus and of the engine that is being used in the project. Provide documentation, including pictures if necessary, demonstrating that the kit is in a “ready-to-install” configuration. If kit design and development, specific to the buses for this project, has yet to be undertaken, provide a detailed procedure, including timeline, of how this process will take place. **Prospective vendors are strongly encouraged to demonstrate the availability of fully vetted installation kits at the time of proposal submission, or, at the very least, to incorporate kit development as part of the pilot portion of the project.**

K. Training

Training is a key component of any retrofit project, not only in the initial stages of ECT installation, but over the course of the program, to ensure proper operation, maintenance and safety. The vendor shall be solely responsible for the training of First Student service technicians and drivers. Training must include both classroom and on-vehicle sessions, and provision of training aids such as instruction and safety manuals and/or video or audio tapes is strongly encouraged. Specific areas that should be incorporated into the training program include:

1. installation;
2. maintenance;
3. in-use vehicle operation;
4. post retrofit troubleshooting & failure mode “limp home”, if applicable; and
5. safety procedures.

The proposal should include brief background descriptions of the instructors selected for in-class and on-vehicle training. Training costs are to be included in the overall budget (see section III.M).

L. In-Use Service and Support

The applicant should provide a plan describing the in-use service support that will be available for the project. At a minimum, issues to be addressed in this section, are:

1. Does the company have its own dealer or distributor network that is available to provide service in a timely manner?
2. Is the dealer or distributor nearby?
3. Does the company intend to rely on First Student for service and support? If so, to what extent?
4. What is the length of time that the company intends to provide service and support as part of this budgetary contract – through ECT

installation, through the warranty period of the ECT, or through the useful operating life of the school bus while it is owned and operated by First Student? Explain fully.

5. It is expected that the vendor will incorporate service and support, at least through the warranty period, as part of the vendor’s total project budget. What budgetary approach will the company select for post-warranty service, if deemed necessary? Will it remain as part of the overall vendor project budget, under a separate service agreement, etc.?

As part of this proposal, all prospective vendors must provide supporting documentation including contact references, substantiating a satisfactory product support record with prior or current projects.

M. Budget

In this section, provide a complete and detailed budget covering technical management, the ECT pilot program, product cost, full fleet installation, product support (maintenance, and warranty support), and training of service and driver personnel. As noted earlier, in-kind contributions for this highly visible project are encouraged.

The table below is provided as a template denoting the major project areas that should be delineated in the budget. It is not necessary to adhere to this format. However, if the applicant chooses an alternative budgetary format, it must, at a minimum, incorporate the project task descriptions, shown below.

Task	Cost	% of Total
Technical Management		
Pilot Program		
ECT Cost		
ECT Installation		
ECT Support (Maintenance & Warranty)		
Personnel Training		
In-Kind Contribution		
TOTAL		

Table 2 – Budget Delineation

IV. Selection Committee

The Selection Committee reviewing all proposals consists of individuals with expertise in the areas of diesel emissions, environmental public policy, fleet management and operations, pupil transportation, and government and regulatory activity. Specifically, these include:

1. Connecticut Department of Environment Protection
2. NESCAUM
3. City of New Haven, Department City Planning
4. New Haven Board of Education
5. First Student, Inc.
6. EPA Region 1

All proposals will be thoroughly reviewed and discussed among the Selection Committee to ensure fairness. *Respondents to this RFP may be contacted prior to final determination of the contract award to clarify specific responses in their proposal, if necessary.*

V. Evaluation Criteria For Selection

Proposal selection will be based upon a number of criteria, enumerated below. No single criterion receives more weighting than another, and proposals will be judged in their entirety in the context of whether they effectively meet the goals of the program, as outlined in section II A. The criterion for evaluation of proposals will reference, at a minimum, the following:

A. Technical Management

Is the company's Project Team well-defined and well-resourced? Is the company's prior technical and management experience consistent with the needs and goals of this project? Is the project management approach clear and concise? Is the record-keeping sufficiently robust for ongoing and future reference?

B. ECT Pilot Program

How well-developed is the Pilot Program in terms of cost, resources, minimal disruption to fleet operations, and schedule? The Pilot Program is essentially a mini-project, and proposals that effectively outline this important phase of the overall program will be favorably judged.

C. ECT Technical Merit and Feasibility

Does the selection of the ECT take into account the school bus operating conditions and fleet type? Is the technology simple to install and maintain? Are installation kits fully developed and available? Is the technology robust, both in

terms of emissions performance and structural integrity? Does the ECT engender safety concerns that a) make it unattractive as a candidate ECT, or b) are safety concerns adequately addressed in the project plan?

D. ECT Environmental Benefits

Are maximum, fleetwide reductions of diesel PM, HC and CO achieved? Is the approach for quantification of these reductions, meritorious and robust? If some form of testing is elected for emission quantification, are the methods scientifically sound? Is ECT performance sustainability over time accounted for and well-documented?

E. Project Support

Does the company have an established dealer support mechanism, including local agents for timely emergency response? Is the support mechanism robust, well-resourced and adequately accounted for in the budget? Does the proposal provide references and historical background from prior projects, substantiating a satisfactory support track-record?

F. Training

Is the training plan sufficiently comprehensive to ensure safe, effective maintenance by service personnel, and vehicle operation by drivers? Are associated training materials, such as texts, audio tapes and/or video tapes, of professional quality and easy to comprehend? Is the background of the instructors well-matched to the product?

G. Timetable for Delivery of Product

Does the proposal clearly outline the prospective vendor's plan to effectively provide "just in time" delivery for ECT product and attendant installation kits? Is a delivery and installation schedule clearly delineated in the proposal. Is product delivery consistent with a projected project starting date of mid-June, with ECT installation continuing throughout the forthcoming summer months?

H. Budget

While budgetary considerations are always a factor in vendor selection, it is imperative that a technical vendor with the proper credentials and qualifications be contracted for this project. As such, the Selection Committee will not necessarily make the contract award to the lowest bidder. Rather, favorable consideration will be given to budgets that are clearly commensurate with the content of the work outlined in the proposal.

Does the budget section clearly delineate costs for the itemized tasks? Is the cost-sharing component consistent with the goals and objectives of the project?

I. Affirmative Action

Please indicate if you are a Minority business enterprise. "Minority business enterprise" means any small contractor or supplier of materials fifty-one per cent or more of the capital stock, if any, or assets of which is owned by a person or persons: (1) who are active in the daily affairs of the enterprise, (2) who have the power to direct the management and policies of the enterprise and (3) who are members of a minority, as such term is defined in subsection (a) of section 32-9n of Connecticut General Statutes; and "good faith" means that degree of diligence which a reasonable person would exercise in the performance of legal duties and obligations. "Good faith efforts" shall include, but not be limited to, those reasonable initial efforts necessary to comply with statutory or regulatory requirements and additional or substituted efforts when it is determined that such initial efforts will not be sufficient to comply with such requirements.

VI. NESCAUM Terms And Conditions

The Terms and Conditions for working as a subcontractor for NESCAUM are included in section VI.A, below.

Please provide a brief *signed* narrative indicating acceptance of these Terms and Conditions. If issues exist with these Terms and Conditions, please provide alternatives and include justification, based upon anticipated risks and benefits to NESCAUM and the New Haven Connecticut School Bus Retrofit Project, underscoring the validity of any proposed surrogate Terms and Conditions.

A. NESCAUM Terms and Conditions

1. NESCAUM is an equal opportunity and affirmative action employer and does not discriminate in its hiring, employment or business practices.
2. NESCAUM is committed to complying with the Americans with Disabilities Act of 1990 and does not discriminate on the basis of disability, in admission to, access to, or operations of its programs, services, or activities.
3. Respondents to the RFP must disclose any current (within the last 3 years) business relationships which may pose a conflict of interest.

4. In no event will NESCAUM or the selected vendor be liable to the other for any lost revenues, lost profits, incidental, consequential, special or punitive damages.
5. Insurance – The contractor shall carry insurance during the term of this contract according to the nature of the work to be performed to "save harmless" the State of Connecticut from any claims, suits or demands that may be asserted against it by reason of any act or omission of the contractor, subcontractor or employees of either the contractor or subcontractor in providing services of this contract. Certificates of such insurance shall be filed with the state agency prior to the contractor's performance of contracted service.

B. Vendor Response

*******End of Request for Proposal*******