Case Study Report

Regional Construction Retrofit Project

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PROJECT DESCRIPTION

Beginning in February 2008, NESCAUM teamed with an aftertreatment equipment vendor and three construction firms to retrofit and field test five large pieces of diesel-powered construction equipment with exhaust aftertreatment devices. The retrofitted equipment was operated at three construction projects: an airport access road development in Manchester, New Hampshire; Route 132 highway expansion in Hyannis, Massachusetts; and site preparation for a mall in Hudson, Massachusetts. The project was primarily funded by a grant from the Environmental Protection Agency (EPA) under the Diesel Emissions Reduction Act (DERA). Cost-share in the form of equipment discounts and in-kind services was also provided by the project partners.

While on-road engines typically are used in a relatively limited set of technical configurations, non-road construction equipment encompasses a wide array of equipment types, hardware configurations, and operating parameters. This diversity is the primary obstacle to extensive installation of emission control technologies, as each configuration and application must be evaluated individually for such factors as space constraints, safety, and duty cycles.

This project sought to resolve engineering challenges presented by the specific configurations by installing EPA- or California Air Resources Board (CARB)-verified diesel particulate filters (DPFs) on construction equipment types in widespread operation throughout the Northeast, thereby facilitating subsequent retrofits on similar machines. The project built on Northeast Diesel Collaborative (NEDC) and individual state initiatives to improve the climate for retrofits in the construction industry and provide a necessary precursor to successful adoption of the NEDC model contract specification.

PROJECT PARTNERS

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PROJECT GOALS

The specific project goals were as follows:

1. Expand the set of field-validated emissions reduction applications by demonstrating EPA- or CARB-verified diesel particulate filters on new applications within the Caterpillar product line.

2. Expand and build momentum for the use of emission control technologies in the construction sector, which accounts for approximately 25 percent of the PM emissions in the Northeast.

3. Increase regional knowledge base and build regional technical capacity for implementing retrofits, as the dealers in New England have little, if any, experience installing control devices on construction equipment.

4. Build an important customer base for future construction sector retrofits, as this is the first retrofit installation for all three construction firm partners.

5. Initiate productive dialogue between regional air agencies, the construction industry, and the state departments of transportation about the importance and feasibility of retrofits and the possibility of funding projects with federal Congestion Mitigation and Air Quality (CMAQ) funds.

PROJECT VENDOR SELECTION

On February 4, 2008, NESCAUM issued a Request for Proposals (RFP) for installation of EPA- or CARB-verified passive diesel particulate filters and received responses from two equipment vendors—Milton CAT and DCL International. On February 21, 2008, NESCAUM awarded the contract to Milton CAT. The decision was based on a number of factors, including 1) CAT offered a lower overall price, reflecting a decision to cost-share on this project; 2) the DCL product was only conditionally verified and therefore new to the market and without robust dealer support; and 3) CAT had a significant dealer network in the region.

Milton CAT was responsible for data logging the engines and confirming other verification requirements, installing the DPFs, installing supports and monitoring systems, making the necessary machine modifications, and providing operator and maintenance training to project partners.

TECHNOLOGIES

All five pieces of equipment were retrofitted with passive, catalyzed continuously regenerating technology (CCRT®) diesel particulate filters, manufactured by Johnson

Matthey. The emission control technology was tested using the required ultra-low sulfur diesel (ULSD) fuel.

VEHICLES/ENGINES INVOLVED

To demonstrate verified DPFs on new applications within the Caterpillar product line, this project targeted two wheel loaders and three hydraulic excavators with hardware configurations not previously retrofitted. Specific vehicles and engines tested were:

Vehicle:	**Engine:**
Caterpillar, Model 980H, Loader	Tier 3, 318 hp, C15
Caterpillar, Model 988H, Loader	Tier 3, 475 hp, C18
Caterpillar, Model 330C, Excavator	Tier 2, 247 hp, C9
Caterpillar, Model 345B, Excavator	Tier 1, 290 hp, 3176
Caterpillar, Model 330D, Excavator	Tier 3, 268 hp, C9

The high-horsepower (475 hp) 988H wheel loader required two DPFs, as shown in Figure 1 and Figure 2, below:

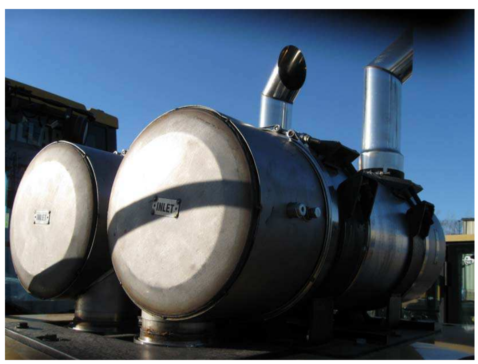

Figure 1: Dual DPFs required by 988H loader

Figure 2: 988H loader retrofitted with dual DPFs, showing shield in place

ENGINE USAGE, BY MACHINE

Total engine run times for each piece of equipment tested are shown in Table 1, below. It was assumed at the project's inception that the equipment would accumulate significantly more run time over the course of the grant period, thereby providing a more robust test of the DPFs. However, economic conditions affecting the construction industry during the grant period resulted in a significant reduction in equipment use. Project partner DW White, in particular, experienced a significant downturn in work, resulting in limited opportunity to utilize the loaders.

Table 1: Total Engine Usage, by Machine

Project partner	Equipment	Install date	Hours at install	Hours at read date indicated	Total run time (hours)
Coleman	Model 330C (excavator)	12.19.08	8,709	10,725 (as of 9.25.09)	2,016
Coleman	Model 345B (excavator)	1.21.09	17,107	18,380 (as of 10.20.09)	1,273
Audley	Model 330D (excavator)	8.13.08	2,287	3,860 (as of 10.23.09)	1,573
DW White	Model 980H (loader)	7.2.08	864	1,401 (as of 10.22.09)	537
DW White	Model 988H (loader)	12.11.08	390	393 (as of 10.22.09)	3

FUEL CONSUMPTION

There was no specific project commitment to track fuel consumption. However, fuel consumption was one of the parameters to be addressed in the final report, along with usage (see Table 1 above). Although direct fuel consumption data were not collected from the project partners, Milton CAT provided estimates of average gallon-per-hour fuel consumption per engine, reported in Table 2 below. These estimates assume normal operating conditions and vary with the duty cycle (e.g., type of work that the machine is doing; how hard the engine is working). Increases in fuel consumption due to the impact of the DPF are assumed to be no more than one percent and likely less. This figure is consistent with data that were gathered during EPA's verification procedure.

Table 2: Estimated Average Fuel Consumption, by Machine

Project partner	Equipment		Estimated fuel consumption (gallons per hour)
	Model	Type	
Coleman	330C	Excavator	13.09
Coleman	345B	Excavator	15.37
Audley	330D	Excavator	14.20
DW White	980H	Loader	16.85
DW White	988H	Loader	25.17

Based on engine hours (Table 1) and estimated per-hour fuel consumption (Table 2), total diesel fuel consumption for the project period is estimated to be 77,415 gallons. If in fact there is a one percent fuel consumption penalty due to the effects of the DPFs, then 767 excess gallons of diesel fuel were consumed over the project period.

EQUIPMENT PERFORMANCE

Operational Issues:
There were some fault code[1] issues with the equipment owned by Coleman and Audley, which were attributed to sensor malfunctions, rather than to actual problems with the DPFs. In addition, there were sensor signal lines that needed repair on both the Coleman and Audley machines. Partial filter plugging episodes were very minor and related to low engine exhaust heat attributable to a light machine duty cycle. None of the filters required manual cleaning during the testing period. However, the need for manual filter cleaning is directly related to the duty cycle of the machine. Therefore the type of work the machine performs will greatly impact the interval at which the filters need to be cleaned, which could be as high as several thousand hours under more optimal conditions.

Maintenance Issues:
Occasionally, if one of the sensors or lines required by the DPFs and their monitors was displaced from its normal operating position, the system would generate a fault code, even though there was nothing functionally wrong with the DPF. Thus maintenance personnel needed to periodically inspect the position and integrity of sensors and lines required by the DPFs and their monitors.

Project Partner Feedback:
The machine operators were interviewed during training/service/inspection calls. The operators noticed that the equipment exhaust was visibly cleaner after being retrofitted with DPFs. Overall the retrofitted equipment operated without problems and received a good review by the project partners. This was consistent with Milton CAT’s experience with passive DPFs, which typically run smoothly when properly fitted and operated.

PROJECTED EMISSIONS REDUCTIONS

Based on known verification numbers for emission reductions, an estimated load factor, and the EPA Emissions Calculator, projected emissions reductions over the life of the retrofits, for each piece of equipment tested, are shown in Table 3 below:

[1] Fault codes are indicators in engine and emission control diagnostic systems that alert operators and maintenance personnel about system problems. Typically if a system malfunctions, the software is programmed to send a specific code to a control panel indicating the nature of the problem.

Table 3: Projected Emissions Reductions, by Machine (over four-year period)

Equipment	Particulate matter (tons)	Carbon monoxide (tons)	Hydrocarbons (tons)
Model 330C (excavator)	0.23	4.08	1.62
Model 345B (excavator)	0.73	15.65	1.90
Model 330D (excavator)	0.25	4.42	1.76
Model 980H (loader)	0.30	5.25	2.09
Model 988H (loader)	0.45	7.84	3.12
Total Emissions Reduced	1.96	37.24	10.49

These projected reductions assume more normal construction activity over a four-year period, in contrast to the considerably reduced activity that occurred in 2009.

LESSONS LEARNED & CONCLUSIONS

Milton CAT is the sole Caterpillar dealer servicing five of the Northeast's eight states, plus the western half of New York State. This project provided the project construction partners with their first experience working with DPFs on machines that are abundant in the project area.

The successful operation of construction equipment that has been retrofitted with a Level 3 verified device[2] (DPF) is dependent on both operator training and maintenance. For this project, Milton CAT worked directly with the project's construction equipment operators and their supervisors to provide appropriate training and outreach. For example, Milton CAT provided job-site training in how to interpret the equipment monitoring panels and how to rethink the equipment operating process by not allowing machines to idle when not in use. Milton CAT believes that their training and outreach programs were key to successful DPF operation on the equipment tested in this project.

In conclusion, this project has provided a solid field demonstration of verified exhaust aftertreatment devices in new applications widely used in the Northeast. In addition to successfully expanding the regional knowledge base and improving regional technical capacity for retrofitting construction equipment with emission controls, this project has contributed to the customer base for future construction retrofit projects.

[2] Level 3 verification is a term used by the California Air Resources Board, referring to those technologies achieving at least an 85 percent or greater reduction in particulate matter or less than 0.01 g/bhp-hr emission level.