CASE STUDIES OF CONSTRUCTION EQUIPMENT DIESEL RETROFIT PROJECTS

July 2009

Manufacturers of Emission Controls Association
1730 M Street, NW * Suite 206 * Washington, DC 20036
www.meca.org
www.dieselretrofit.org

Table of Contents

1.0 INTRODUCTION

Diesel engines provide important fuel economy and durability advantages for large heavy-duty trucks, buses and nonroad equipment. Although they are often the power plant of choice for heavy-duty applications, they have the disadvantage of emitting significant amounts of particulate matter (PM) and the oxides of nitrogen (NOx) and lesser amounts of hydrocarbon (HC), carbon monoxide (CO) and toxic air pollutants.

Due to the lack of emission control regulations until 1996, diesel engines used in construction equipment are more polluting than those used for normal highway applications. It is estimated that 47 percent of mobile source diesel PM emissions nationwide comes from nonroad diesels and 25 percent of mobile source NOx comes from nonroad diesels. The reduction of the diesel emissions from construction equipment has the potential to significantly improve air quality for those who live or work in or adjacent to construction sites. With the approval of the U.S. EPA Clean Air Nonroad Diesel Rule (see www.epa.gov/nonroad-diesel/2004fr.htm) that is scheduled for implementation in 2008-2015 timeframe, diesel emissions reduction from nonroad engines will occur through the use of advanced diesel engine technology, ultra-low sulfur diesel fuel (15 ppm S max.), and advanced diesel exhaust emission control technology such as diesel particulate filters (DPFs) for reducing PM emissions, and selective catalytic reduction (SCR) systems and NOx adsorber catalysts for reducing NOx emissions. These EPA Tier 4 emission standards for nonroad engines will apply to diesel engines used in most kinds of construction, agricultural and industrial equipment. Technologies for complying with the Tier 4 nonroad diesel regulations will flow from the experience gained in complying with EPA's 2007-2010 heavy-duty highway diesel program (see www.epa.gov/OMSWWW/diesel.htm). However, due to the long operating lives of these diesel engines, it will take decades for older, "dirtier" nonroad diesel engines to be replaced with the mandated newer "cleaner" engines. Given the health and environmental concerns associated with diesel engines and because the nonroad engines make up a significant percentage of diesel pollution emitted, there is an increasing interest in retrofitting the older nonroad diesel engines.

The case studies discussed in this paper focuses on those projects that have been completed, are in progress, or have received funding for retrofitting diesel-powered construction equipment with emission controls technology. Many of the projects highlight the feasibility of installing verified onroad technologies on construction equipment and relate some of the lessons learned that may assist others in planning new construction equipment retrofit projects. The limited range of experience with retrofits on construction equipment summarized in this report also serves to point out the need for expanding the range of verified retrofit technology options for nonroad diesel applications in general, and construction equipment in particular. This paper focuses on technology based strategies and where available, provides information on specific type of technology installed on the type of construction equipment, and the emission reduction that was achieved. For more detailed descriptions of available diesel exhaust emission control technologies that can be retrofit on existing onroad and nonroad diesel engines, please see MECA's companion white paper, *Retrofitting Emission Controls On Diesel-Powered Vehicles,* available on either www.meca.org or the MECA retrofit dedicated website, www.dieselretrofit.org.

2.0 COMPLETED OR CURRENT PROJECTS

2.1 The Central Artery/Tunnel (CA/T) Project, Boston, MA

The Central Artery/Tunnel (CA/T) Project, also known as the "Big Dig", is a major highway construction project designed to reduce traffic congestion and improve mobility in central Boston. The Central Artery/Tunnel project was under construction for over 15 years beginning in 1991. One of the largest construction projects in the country, it was designed to bury the existing 7.5 mile, six-lane elevated portion of I-93 running through central Boston. The construction included moving over 13 million cubic yards of excavated material and placing four million cubic yards of concrete. The project required the use of heavy-duty construction equipment in a concentrated area. To minimize the impact of the equipment on air quality of surrounding Boston neighborhoods, Massachusetts Turnpike Authority, in collaboration with other government and private organizations, implemented a construction equipment retrofit program starting in 1998. Under a Clean Air Construction Initiative Program, 25 percent of long-term nonroad diesel equipment used in constructing the CA/T Project was retrofitted with advanced pollution control devices, with more than 200 pieces of equipment retrofitted.

Because it was the first program of its kind, the retrofits were completed in three phases. During the first phase, eight pieces of equipment from three different contractors were retrofitted. These included both large and small excavators and large and small front-end loaders from several different manufacturers. When the first phase proved that equipment could be easily retrofitted without causing excessive down time or ongoing operational problems, the program was extended to the second phase and 60 pieces of equipment were retrofitted. In the third phase, retrofit requirements were put into the final contracts, resulting in an additional 150 pieces of equipment being retrofitted. The construction equipments were retrofitted with diesel oxidation catalysts (DOCs) over diesel particulate filters (DPFs) because of the reduction in hydrocarbon (HC) associated with diesel odors and carbon monoxide (CO) and PM_{10} provided by DOC, the ease of installation and maintenance, and the cost of a DOC compared to DPF that allowed more pieces of equipment to be retrofitted with the available funds. In addition to retrofitting with emission control devices, the project included assigning staging zones for waiting trucks and limiting idling to not more than five minutes. The construction equipment was also refueled with ultra-low sulfur diesel (ULSD) and emulsified diesel fuels.

Equipment retrofitted with DOCs includes:

- Nichi, Caterpillar, SIC, Terex, and JLG lifts
- Mantis cranes
- John Deere and Caterpillar dozers
- Cradel excavators

The model years of the equipment ranged from 1994 to 2000, with most of the equipment being 1999 or 2000 model year. According to the contractors, the equipment retrofitted with DOCs has not experienced any adverse operational problems, such as loss of power or additional fuel consumption. During the pilot program, the Environment Canada used a portable emission-testing device and several DOCs were removed and sent to Environment Canada for emission testing in subsequent evaluations.

Preliminary estimates from 2000-2004 of area-wide emission reductions from the retrofitted equipment indicate a reduction of approximately:

- 36 tons/year of CO,
- 12 tons/year of HC, and
- 3 tons/year of PM

More information on this project can be found at: http://www.massturnpike.com/bigdig/background/airpollution.html.

2.2 I-95 New Haven Harbor Crossing Corridor Improvement Program, New Haven, CT

Started in 2002, the New Haven Harbor Corridor Crossing Improvement Program is a major road project along seven miles of the I-95 corridor in southern Connecticut. Project work includes the widening of I-95 between New Haven and Branford, CT; reconstruction of the I-95/I-91/I-34 interchange in New Haven, and replacement of the existing Pearl Harbor Memorial Bridge over New Haven Harbor with a new ten-lane bridge. The construction first began in June 2004 and the entire project is expected to be completed by 2014. As part of the Connecticut's Clean Air Construction Initiative, contractors were required to either retrofit their equipment with DOCs or use alternative clean fuels. The construction contractors have also volunteered to use low sulfur diesel (500 ppm sulfur) on all of their nonroad equipments. The Initiative was established to protect workers and residents from harmful construction emissions along a populated corridor. The contractors are required to implement the following:

- Install emissions control devices on nonroad diesel-powered construction equipment with engine horsepower ratings of 60 hp and above, that are on the project or assigned to the contract for more than 30 days;
- Truck staging zones will be established for diesel-powered vehicles to wait to load or unload;
- Idling is limited to three minutes for delivery and dump trucks and other diesel-powered equipment, with some exception;
- All work must be conducted to ensure that no harmful effects are caused to adjacent sensitive areas;
- Diesel-powered engines must be located away from fresh air intakes, air conditioners, and windows.

To date, all contractors have chosen the retrofit option. Six different contractors have already installed DOCs on 100 pieces of equipment used on the project, including cranes, sweepers, rollers, excavators and man lifts. Before the project is completed, it is expected that up to 150 pieces of equipment will be retrofitted with DOCs. Some of these DOCs have now been in use on site for over 45 months, and have accumulated over 5,000 hours of service with few complaints from the contractors about increased fuel use, down-time or increased maintenance costs. More information on this project can be found at:

http://www.i95newhaven.com/poverview/environ_init.asp.

2.3 WTC Diesel Emissions Reduction Project

The 7 WTC Diesel Emissions Reduction Project is a national model for demonstrating clean construction by using ULSD and retrofit nonroad, heavy-duty diesel construction equipment with DOCs or DPFs. The WTC Diesel Emissions Reduction Project is the first public/private initiative in New York construction market focused on reducing emissions from heavy-duty diesel construction equipment that was initiated by the Clean Air Communities (CAC). The project plan calls for immediate use of ULSD fuel for selected equipment on-site and the phase-in of retrofit technologies on equipment owned by participating contractors or sub-contractors working at the 7 WTC site. CAC provides technical support and funding to construction contractors working at 7 WTC to implement ULSD fuel and to retrofit selected equipment. Funding has also been provided to construction corporations and transit fleets operating in the vicinity of 7 WTC in partnership with the Battery Park City Authority. The CAC project will retrofit 8 pieces of construction equipment at the WTC site and 10 pieces of equipment will use the ULSD fuel. More information on this project can be found at: www.cleanaircommunities.org/projects/wtc.html.

In order to investigate diesel emission reduction from nonroad construction equipment at the World Trade Center, the Port Authority of New York and New Jersey initiated a project designed to investigate the use of emission reduction strategies for several pieces of equipment with focus on PM reduction. The construction equipment selected for the project included two Caterpillar 966G wheel loaders and one Caterpillar 2,000 kW generator. First of the emission reduction strategy was to switch the fuel to ultra low sulfur diesel (ULSD) fuel and then the wheel loaders were retrofitted with DPFs. DPFs installed for the project utilized passive regeneration technology. Caterpillar, Inc. installed the DPF into the wheel loader exhaust system with a complete retrofit replacement kit that is a direct replacement for the original muffler. Because it was determined that the generator was unsuitable candidate for a DPF due to the lack of sufficient exhaust temperature, no emissions test was conducted on the generator. To quantify the emission reduction achieved with the ULSD and DPF, portable emission monitoring systems (PEMS) were installed on the wheel loaders. Two independent portable systems were installed simultaneously because no one system can provide the emission measurement metrics requested by the Port Authority: 1) the Clean Air Technologies International Montana system, and 2) the Environment Canada DOES2 system. Emission testing on the wheel loaders was performed to determine reduction efficiency performance of deploying ULSD and a DPF with ULSD against onroad diesel fuel. Emission testing was performed over a two-week period. The two loaders, TG-22 and TG-25 were exercised through a complete testing sequence one at a time. The following testing sequence was used:

- DPF and ULSD;
- OEM muffler and ULSD; and
- OEM muffler and on-road diesel fuel

The tests were run for each configuration until a minimum of three acceptable test runs were established. The test results are as follows:

PM Emissions Result:

Significant PM emission reductions were documented as a result of implementing ULSD and installing DPFs. Both of the portable emissions monitoring systems found PM emission reduction in the 15 to 20 percent range when just ULSD was used and greater than 90 percent reduction when ULSD was combined with a DPF.

Table 1: PM Emission Test Results

Fuel	Retrofit Technology	Environment Canada PEMS		CATI PEMS	
		g/gal	% reduction	g/gal	% reduction
On-road diesel	None	3.964	---	1.551	---
ULSD	None	3.464	12.6	1.289	16.9
ULSD	DPF	0.100	97.5	0.011	99.3

CO Emissions Result:

Significant CO emission reductions were observed during this program when the DPF was employed.

Table 2: CO Emission Test Results

Fuel	Retrofit Technology	Environment Canada PEMS		CATI PEMS	
		g/gal	% reduction	g/gal	% reduction
On-road diesel	None	25.64	---	25.23	---
ULSD	None	22.98	10.4	24.84	1.5
ULSD	DPF	3.43	86.6	2.15	91.5

HC Emissions Result:

Results from switching from onroad diesel to ULSD alone indicate a net increase in HC emissions. However, a 97 percent reduction is achieved by switching to ULSD and using the DPF.

Table 3: HC Emission Test Results

Fuel	Retrofit Technology	Environment Canada PEMS	
		g/gal	% reduction
On-road diesel	None	1.26	---
ULSD	None	1.93	-52.7
ULSD	DPF	0.03	97.4

Note: Because the CATI Montana system is not equipped with a heated sample line, the HC total mass and real-time data is considered anecdotal and is not presented.

NOx Emissions Result:

The program as developed by the Port Authority did not target NOx reductions, and the emission test results indicate approximately 16 percent reduction as a result of switching fuels and between about 20 to 30 percent by using the DPF. Applications of DPFs is not expected to impact NOx emissions and the results reported here may be related to engine backpressure effects associated with operations utilizing a DPF.

Table 4: NOx Emission Test Result

Fuel	Retrofit Technology	Environment Canada PEMS		CATI PEMS	
		g/gal	% reduction	g/gal	% reduction
On-road diesel	None	100.0	---	123.0	---
ULSD	None	84.5	15.6	103.7	15.7
ULSD	DPF	80.4	19.7	87.93	28.5

CO_2 Emissions Result:

The test results show that there was little difference in CO_2 results between fuel/retrofit technology configurations. The reductions shown are partially attributable to the differences in hydrogen and carbon content of the two fuels.

Table 5: CO_2 Emission Test Result

Fuel	Retrofit Technology	Environment Canada PEMS		CATI PEMS	
		g/gal	% reduction	g/gal	% reduction
On-road diesel	None	10,275	---	11,808	---
ULSD	None	9,714	5.5	11,298	4.3
ULSD	DPF	9,749	5.1	11,340	4.0

More information on this project is available at: www.mjbradley.com/documents/PANYNJ_WTC_Final_Report-09Aug04.pdf.

2.4 New South Ferry Terminal Project

The South Ferry Terminal project was the first lower Manhattan reconstruction project after the attacks of September 11, 2001, and the first major subway tunnel and station construction/expansion project within New York City in 100 years. Construction started in 2005 and was completed in 2008. Deep tunnel excavation, and construction of the concrete structural box, required a significant deployment of equipment and at any given time, there were 70 to 100 pieces of diesel equipment in use on the site. Coordinating agencies implemented a set of Environmental Performance Commitments (EPCs) to minimize the environmental impacts of rebuilding on lower Manhattan. The EPCs required the implementation of emission control measures on all diesel construction equipment used for the South Ferry Terminal project. The Air Quality Environmental Performance Commitments are:

- Use ULSD fuel for all nonroad diesel construction equipment;
- Use retrofit technology (primarily DPFs) for all nonroad equipment with engines of 50 hp or more and meet EPA's Tier II emission standards;
- Limit unnecessary idling times on diesel powered engines to three minutes;
- Locate diesel powered exhausts away from fresh air intakes; and

- Control dust at construction sites.

At any given time, there were 70 to 100 pieces of diesel equipment in use at the South Ferry Terminal construction site. A significant variety of equipment ranging in size from 60 hp to over 500 hp were retrofitted with DPFs. More information on this project is available at: www.mta.info/capconstr/sft/environmental.htm.

2.5 Croton Water Treatment Plant Project

The Croton Water Treatment Plant Project is the first project that focused on implementation of "Best Available Technology" (BAT) in accordance with the New York City Local Law 77 (LL77) for nonroad construction equipment. Following the enactment of NYC LL77 in 2003, the City of New York Department of Environmental Protection led the first implementation of BAT at the Croton Water Treatment Plant (CWTP), requiring retrofit of diesel exhaust emission controls on nonroad construction equipment and cement trucks and the use of ultra-low sulfur diesel fuel (ULSD). The project involved identifying and deploying emission control technologies on off-road, heavy-duty construction equipment owner or leased, operated and maintained by Schiavone Construction Company for construction activities at the CWTP in Bronx, NY. The emission control technology performance evaluation and ULSD fuel supply properties analysis were performed under real-world operating conditions.

A total of 37 nonroad construction equipment were inventoried at the CWTP site, categorized into six major groups. Due to prior contractual arrangement between the general contractor and NYCDEP, the engines in most of the equipment on site were EPA Tier 2 certified or higher. The total population of 37 nonroad equipment was comprised of: 5 compressors, 2 bulldozers, 6 excavators; 15 hydraulic drills, 3 loaders, and 6 quarry trucks. To suit the overall project objectives and in-use emission test design, equipment was divided into three categories: 1) non-BAT equipment; 2) BAT retrofitted equipment; and 3) BAT retrofitted with in-use emission tests performed.

All but three pieces of equipment were retrofitted with passive DPFs, active DPFs, and SCR + passive DPF. From all of the retrofitted pieces of equipment, six representative equipment were selected for ISS testing. Four different types of retrofit technologies were installed on these six nonroad equipment:

- A SCR+PDPF system was retrofitted onto a compressor. A catalyzed cordierite wall flow filter reduces PM, CO, and HC emissions and the SCR catalyst controls NOx emissions.
- Passive DPFs that were installed on the Komatsu Dozer, Komatsu Excavator and Tamrock Tiger Drill are made of silicon carbide substrate and continuous passive filter regeneration occurs during a vehicle duty cycle when the exhaust temperatures are above 325°C. This normally occurs for more than 25% of the operational time of the equipment. The catalyst also oxidizes a high proportion of the CO and HC emissions. The filter substrate is coated with a proprietary catalytic layer to reduce soot combustion temperature to a level within the normal exhaust temperature range. The PDPF is EPA and ARB (Level 3) verified and achieves 80-90% PM reduction.

- The active DPF was installed on a Terex quarry truck that regenerates through on-board electrical regeneration. The device is ARB verified at Level 2 for stationary back-up generators (BUGs) and ARB Level 3 verification for BUGs is in process. The ADPF is used with a DOC to further reduce CO and HC in the engine exhaust downstream of the ADPF.
- The catalyzed DPF was installed on a Caterpillar Rubber Tire Loader. The catalyzed DPF oxidizes PM in the presence of NO_2 at a lower temperature than with oxygen. This lower temperature is comparable with typical diesel exhaust temperature so no additional heat is required. The catalyzed DPF contains a substrate coated with a proprietary, highly-active platinum oxidation catalyst designed to oxidize a portion of the NO in the exhaust to NO_2. The NO_2 generation is the key to the oxidation of PM collected by the wall-flow filter. The catalyst also converts CO and HC into CO_2 and H_2O.

Type	Engine	HP	Tier	Retrofit Technology
Compressor	John Deere	170	2	SCR+PDPF
Dozer	Komatsu	332	2	PDPF
Excavator	Komatsu	474	2	PDPF
Quarry Truck	Detroit Diesel	700	2	ADPF
Rubber Tire Loader	Caterpillar	259	2	Catalyzed DPF
Tiger Drill	Caterpillar	173	2	PDPF

In-use emissions measurements were conducted using Dynamic Dilution On/Off-road Exhaust Emissions Sampling System (DOES2). The DOES2 system is a portable emission measurement system that has been successfully used on a number of projects including work on construction equipment at the World Trade Center in Lower Manhattan and in Houston, TX. Testing included the evaluation of the following EPA-regulated criteria pollutants: particulate matter; total hydrocarbons; oxides of nitrogen; and carbon monoxide. Additional emission constituents that were also evaluated include: NO/NO_2 split; carbon dioxide; ammonia; and fuel consumption (as determined by a calculation based on the carbon emissions). To comply with DEP contract requirements, all nonroad construction equipment on-site (BAT and non-BAT) were fueled with ultra-low sulfur diesel (ULSD) fuel containing a maximum sulfur-level of less than 30 ppm by weight. Fuel samples were obtained and periodically tested on selected pieces of equipment operating on the site to ensure compliance with the use of ULSD.

Test Results:

Emission testing results for Ingersoll Rand Compressor IR 600:

Emission Type	Measurement	Average Result (g/min)	% Reduction
TPM	Baseline	0.176	96.6
	SCR+PDPF	0.006	
HC	Baseline	0.266	93.6
	SCR+PDPF	0.017	
NOx	Baseline	5.27	66.6
	SCR+PDPF	1.76	
CO	Baseline	0.629	96.8
	SCR+PDPF	0.02	

Emission testing results for Komatsu D155-Ax-5B Dozer:

Emission Type	Measurement	Average Result (g/min)	% Reduction
TPM	Baseline	0.672	98.1
	PDPF	0.013	
HC	Baseline	0.174	92.5
	PDPF	0.013	
NOx	Baseline	14.4	4.9
	PDPF	13.7	
CO	Baseline	10.2	98.7
	PDPF	0.132	

Emission testing results for Komatsu PC750 Excavator:

Emission Type	Measurement	Average Result (g/min)	% Reduction
TPM	Baseline	0.583	99
	PDPF	0.00	
HC	Baseline	0.296	79.1
	PDPF	0.062	
NOx	Baseline	21.7	11.5
	PDPF	19.2	
CO	Baseline	3.83	98.3
	PDPF	0.064	

Emissions testing results for Terex TR70 Quarry Truck:

Emission Type	Measurement	Average Result (g/min)	% Reduction
TPM	Baseline	0.353	44.8
	ADPF	0.195	
HC	Baseline	0.458	30.5
	ADPF	0.318	
NOx	Baseline	18.4	2.7
	ADPF	17.9	
CO	Baseline	9.05	33.6
	ADPF	6.01	

The reductions in NOx from the quarry truck is not deemed statistically significant because it was discovered after testing had been completed that internal damage has been done to the filter and provides a likely explanation for the filter's lower reported emission reduction efficiency.

Emissions testing results for Caterpillar 966G Rubber Tire Loader:

Emission Type	Measurement	Average Result (g/min)	% Reduction
TPM	Baseline	0.182	99
	Catalyzed DPF	0.000	
HC	Baseline	0.120	80.8
	Catalyzed DPF	0.023	
NOx	Baseline	6.47	7.4
	Catalyzed DPF	5.99	
CO	Baseline	2.11	93.3
	Catalyzed DPF	0.141	

Emissions testing results for Tamrock CHA 700 Tiger Drill:

Emission Type	**Measurement**	**Average Result (g/min)**	**% Reduction**
TPM	Baseline	0.194	98.9
	PDPF	0.002	
HC	Baseline	0.124	51.6
	PDPF	0.060	
NOx	Baseline	7.47	5.1
	PDPF	7.09	
CO	Baseline	0.669	99
	PDPF	BDL[1]	

[1] BDL: Below Detection Limit

Conclusion:

The in-use testing confirmed EPA and ARB verification level performance about the emission removal efficiency of the different types of LL77 Category I emission control technology types on the six equipment types at the CWTP. The test data showed significant PM-reduction on a mass basis from the PDPFs installed on the bulldozer, excavator, wheel loader and hydraulic drill. HC and CO reduction followed a similar pattern. While the ADPF installed on the Terex quarry truck experienced an internal structural failure due to excessive stress and vibration, it still reduce PM emissions by over 45% and is expected to achieve greater than 90% when repaired. Additionally, the SCR+PDPF equipped compressor reduced PM by over 95% and NOx by over 65%. The test result and analysis provide quantitative support for the continued application of BAT as an effective approach to aggressive reduction in PM, HC, CO and NOx, where applicable.

More information on this project is available at: http://www.emisstar.com/docs_and_pdfs/croton_cumulative_reductions.pdf.

2.6 LAX Master Plan Program: Community Benefits Agreement

As part of the LAX Master Plan Program, the Community Benefits Agreement provides a range of community benefits and impact mitigations that will be implemented by the Los Angeles World Airports (LAWA). Included in this Agreement is the requirement to retrofit all diesel construction equipment with best available emissions control devices to firstly reduce diesel PM and then NOx secondly. This requirement for retrofit applies to all diesel-powered nonroad equipment, onroad equipment, and stationary diesel engines. The emission control devices must be verified or certified by EPA or ARB for onroad or nonroad vehicles. Additionally, as part of a Demonstration Project, LAWA may allow diesel construction equipment used at a LAX Master Plan Program construction site to be retrofitted with a new emission control device that have not yet been certified or verified by ARB or EPA for use for onroad or nonroad vehicles or engines. LAWA, in consultation with the Coalition Representative and LAWA contractors, must develop processes to determine if a Demonstration Project using a new emission control device is needed, and how the project will be implemented. All emission control device installed on the diesel engines must achieve emission reduction no less than the reduction that could be achieved by an ARB Level 2 device (50-85% PM reduction efficiency). The emission reduction device may not increase the emission of any pollutant above the level that is standard for that engine. In order to determine the best available emission control devices for new technology that may become available in the future, the new emission control devices must meet a cost-effectiveness threshold of $13,600 per ton of NOx reduced. For $PM_{2.5}$ and PM_{10} reduction, any diesel particulate filter, diesel oxidation catalyst, or other technology on EPA or ARB verified list are considered to be cost-effective.

In addition to diesel construction equipment retrofit requirement, all construction equipment used for LAX Master Plan Program must use ultra-low sulfur diesel (ULSD) fuel, provided that there is an adequate supply in the Southern California area. If adequate supply of ULSD is not available, other fuels that do not emit greater emissions of fine PM or NOx than would using ULSD, could be used.

Designation of the best available emission control devices will be reassessed annually and LAWA must establish processes to revise these designations and include them into construction bid documents before bidding of new construction phases of the LAX Master Plan Program. LAWA must also ensure that the requirements for installing diesel emission control devices and the use of ULSD are followed by all Airport Contractors, Airport Lessees, and Airport Licensees. Violation of these requirements is subject to a fine of $1,000 per day per violation. Compliance with these requirements will be monitored by an independent third party monitor. Diesel equipment manufactured before 1990 must be retrofitted with DOCs verified by ARB for use on nonroad diesel engines by December 31, 2005. If no verified DOC exists for the particular diesel equipment on or before June 30, 2003, the installation schedule is delayed until ARB can make the appropriate findings to support verification. If ARB verified DPFs are shown to be available and technically feasible, safe, reliable and cost effective for the pre-1990 diesel equipment, it must be retrofitted with the DPF by December 31, 2010. For diesel equipment that is manufactured in or after 1990, verified DPFs or verified DOCs must be installed within 36 months of ARB verification of the technology.

More information on the Community Benefits Agreement is available at: http://www.laane.org/lax/index.html.

2.7 Dana-Farber Yawkey Center for Cancer Care Diesel Retrofit Project

The Dana-Farber Yawkey Center for Cancer Care is a 275,000 square foot clinical research and treatment facility being constructed in the heart of the Longwood Medical Area in Boston, MA. The completed facility will include seven levels of underground parking and a 13-story tower rising out of a densely packed neighborhood. The construction started in 2006 and is expected to be completed in 2011. Dana-Farber enacted a requirement for emissions retrofits on the diesel construction equipment used on the project. The specifications include a strict no-idling policy, encourage the use of electric-powered equipment where feasible, and require minimum pollutant reduction of 42% for VOCs, 31% for CO, and 23% for PM. Subcontractors were encouraged to use a combination of retrofit technologies and cleaner fuels to meet these specifications.

Under the program, 17 pieces of equipment have already been retrofitted with DOCs. By the end of the project, it is expected that a total of 25 to 30 pieces of construction equipment will have emissions reduction technology installed. All retrofit equipment will also use ULSD fuel while on site. The retrofitted equipment ranges from loaders, to slurry pumps, to specialized cranes. Subcontractors have not reported any changes to equipment operation or fuel consumption after being retrofitted. Dana-Farber Cancer Institute is pleased with the outcome of the endeavor, and has added clean diesel/emissions reduction requirements to its Institutional Master Plan. As a result, all future Dana-Farber projects will include clean diesel specification in the contract language. More information on this project is available at: www.epa.gov/diesel/construction/casestudies.htm.

2.8 ARB Off-Road Diesel Retrofit Showcase Program and Supplemental Environmental Projects

The California Air Resources Board in conjunction with the South Coast Air Quality Management District (AQMD) and the Mobile Source Air Pollution Reduction Review Committee (MSRC) have implemented a program to demonstrate the viability of diesel emission control devices in a variety of off-road engines and to obtain new emission control systems that will be verified by the ARB prior to new off-road regulations currently under development. This project provides an opportunity for manufacturers of diesel emission control technologies to participate with fleet owners in retrofitting off-road engines with a diesel emission control device to reduce PM or PM and NOx. Fleet owners benefit from this program by gaining early compliance of new emissions standards set to go into effect in 2010 at reduced or no cost to themselves. The MSRC contributed $3.6 million in funding and the SCAQMD added an additional $1.2 million (to be used specifically for PM+NOx retrofits) to help fund the program.

This program is open to manufacturers who have previously received verification from the EPA's Voluntary Retrofit Program, ARB's Verification Procedure, or the Verminderung der Emissionen im Tunnelbau (VERT) program. Verification may be from a previous on-road or off-road verification. Within the project, there are two different technologies that could be implemented to minimize diesel emissions. These include passive and active engine retrofit technologies, depending on the temperature profile of the vehicle. Data loggers were installed on the vehicles of interest. There are 18 fleet owners involved in the project: 5 public fleets and 13 private fleets, which account for a total of 186 vehicles. In total, 16 emission control manufacturers are contributing to the project: 11 active diesel particulate filters and 18 passive diesel particulate filters. To date, 13 off-road vehicles have been retrofitted.

In addition to the Off-Road Diesel Retrofit Showcase, ARB is also retrofitting off-road diesel engines with funds from Supplemental Environmental Projects to demonstrate additional technologies. The SEP is divided into 4 phases:

- SEP I: 16 vehicles retrofitted with $300,000 in funding;
- SEP II: 10 of 11 vehicles retrofitted to date with $200,000 in funding;
- SEP III: 2 of 11 vehicles retrofitted to date with $200,000 in funding;
- SEPA IV: 8 vehicles identified for retrofit with $250,000 in funding.

More information on these off-road programs is available at: http://www.arb.ca.gov/diesel/showcase/showcase.htm.

2.9 Dan Ryan Expressway Road Construction Project

The Illinois Department of Transportation (IDOT) implemented a pollution reduction initiative on the reconstruction project of the Dan Ryan Expressway that runs through the middle of the south side of Chicago. Through this project, all heavy construction equipment on the Dan Ryan project was either retrofitted with emissions control device or used ULSD fuel (15 ppm sulfur). IDOT had also implemented idling limits and dust controls to reduce air emissions from construction activities. An estimated 290 pieces of construction equipment in use on the Dan Ryan project had emissions control device or used ULSD. Funded in part through a grant of $60,000 from U.S. EPA, these emissions control strategies were a contract requirement for equipment operating on the Dan Ryan project. The focus of this project was on reduced idling, with contractors required to establish truck staging areas while waiting to load or unload, and the idle time was limited to no more than 5 minutes. The Illinois Tollway Authority has also adopted IDOT's Initiative and is requiring the use of either ULSD fuel or retrofitting heavy construction equipment on the reconstruction and widening projects along several highways. The project was completed in August 2007. More information on this project can be found at: www.danryanexpressway.com.

2.10 The Impact of Retrofit Exhaust Control Technologies on Emissions from Heavy-Duty Diesel Construction Equipment (SAE paper no. 1999-01-0110)

The testing program was conducted to study the in-use emissions and duty cycles from five heavy-duty construction vehicles and examine the emission reduction potential of retrofit control technologies on construction equipment, such as DOCs, passive DPF, and active DPF technologies. For this study, the following emissions reduction devices were installed:

- Backhoe was equipped with an active uncatalyzed particulate filter that was designed to operate a full shift and then at the end of the shift, regenerate using in-line electrical burners powered by 220 V shore power. The substrate was a 100 cells/inch^2 cell wall flow filter.
- Volvo front end loader was retrofitted with an oxidation catalyst with substrates in parallel 19 cm diameter and 13 cm length. The catalyst contained 300 cells/inch^2 and had a total volume of 7 liters. The catalyst washcoat contained a proprietary zeolite and the precious metal catalyst is platinum based. The unit was a direct replacement of the stock muffler.
- Caterpillar front end loader was retrofitted with a catalyzed particulate filter 100 cells/inch^2. The washcoat is a proprietary precious metal coating.
- Dump truck was retrofitted with an oxidation catalyst that is 3 cm in diameter. The catalyst contains 300 cells/inch^2 with a proprietary precious metal washcoat. The catalyst was a direct replacement of the stock muffler.
- Bulldozer was retrofitted with an oxidation catalyst specifically designed for this application. It contains 200 cells/inch^2 and has a proprietary precious metal coating.

After conducting the tests on each of the five construction equipments along with baseline emissions tests, it was concluded that:

- Dumptruck, equipped with DOC, showed PM reduction of 17%; however, the conversion of the gaseous emissions was low;
- Backhoe, equipped with active DPF, showed PM reduction of 81%;
- Bulldozer DOC system showed PM reduction of 24%, CO emissions were also significantly reduced while HCs were not reduced;
- Caterpillar wheeled loader, equipped with catalyzed DPF, showed a combination of 97% PM reduction and excellent gaseous control; and
- Volvo wheeled loader, equipped with DOC, showed PM reduction of 52% (during the tests a leak developed in the mass flow controller and made it difficult, if not impossible to determine the absolute emission rates).

This test program confirmed that retrofitting exhaust emission control technologies to nonroad construction equipment is feasible and that real in-use emission reductions can be achieved. Based on the results of this study, retrofitting 200,000 diesel construction equipment with DOCs in the Northeast would reduce PM emissions up to 4,000 tons/year, CO up to 45,000 tons/year, and HCs up to 7,000 tons/year. Retrofitting 200,000 construction equipments with DPFs would reduce PM emissions up to 15,000 tons/year, CO up to 109,000 tons/year, and HCs up to 17,000 tons/year.

2.11 Demonstration Projects for Diesel Particulate Filter Technologies on Existing Off-Road Heavy-Duty Construction Equipment

The South Coast Air Quality Management District (SCAQMD) and California ARB jointly initiated a project to evaluate the durability and effectiveness of passive DPF technology installed on existing nonroad diesel construction equipment. The focus of the project was the installation of 21 PM filters onto 15 diesel engines that are used on 12 heavy-duty construction vehicles. The demonstration study comprised of engineering and retrofitting the construction equipment and monitoring their operation for a period of one year. The effectiveness and durability of the filters and their installation hardware were measured and laboratory dynamometer emission testing under various steady-state and transient conditions was also conducted. The Los Angeles County Sanitation District (LACSD) provided six vehicles (scrapers and dozers) that were fueled with ULSD fuel and two scrapers and two dozers were also operated as control vehicles to provide baseline information for fuel economy, oil consumption, and reliability performance against the vehicles retrofitted with the DPFs. C.W. Poss Construction, Inc. (Poss) also provided six vehicles (scrapers and dozers) as the study vehicles but did not operate any control vehicles. Two different manufacturers provided the DPFs for the construction equipment.

Vehicles and DPFs used:

- LACSD vehicles: 1996 vintage 657 E scrapers, and 2000 vintage D9 dozers
- Poss vehicles: Caterpillar 651 B scrapers and Caterpillar 824/825/834 series dozers manufactured between 1971 and 1983

- DPFs from supplier A: 20"x15" filters for all applications, except for one 15"x15" used on an 825C dozer with a Caterpillar 3406 engine
- DPFs from supplier B: 20"x15" filters on most applications

The final equipment selections are as follows:

- A total of 12 vehicles were retrofitted in the study: 6 with DPFs from supplier A and 6 with DPFs from supplier B; with 6 of the test vehicles located at LACSD and 6 at Poss
- A total of 15 engines were retrofitted: 8 with DPFs from supplier A and 7 with DPFs from supplier B; with 9 located at LACSD and 6 at Poss
- A total of 21 filters were involved in the program: 12 from supplier A and 9 from supplier B; with 12 located at LACSD and 9 located at Poss

After operating these construction equipments with DPFs for a period of one year, filters from suppliers A and B were tested at the West Virginia University (WVU) Engines and Emissions Research Laboratory. Dynamometer tests on a Caterpillar engine using both transient and 8-mode steady-state duty cycles were conducted. The test showed that DPFs from both suppliers were highly effective in reducing PM emission on the dynamometer tests. Both pre- and post-demonstration testing by WVU on the filter from supplier B showed more than 98 percent PM emissions reduction. Pre-demonstration test of the filter from supplier A showed greater than 98 percent PM emissions reduction, while the post-demonstration testing showed approximately 91 percent PM emission reduction. None of the filters from suppliers A and B affected the levels of total NOx significantly, while the traps greatly reduced the levels of HC and CO emissions (about 79 and 65 percent for the filter from supplier A, respectively, and 93 and 97 percent for the filter from supplier B, respectively).

Table 1: Post-Demonstration Dynamometer Emissions Test Results

Emission Type	Fuel Type	8-mode Weighted Average (g/bhp-hr)	Transient Cycle (g/bhp-hr)	% Reduction vs. ECD1 Baseline (Transient Test)
PM	ECD1 Baseline	0.17	0.33	0%
	EDC1-Supplier B	0.01	0.00	>99%
	EDC1-Supplier A	0.01	0.03	90.9%
NOx	ECD1 Baseline	6.52	6.40	0%
	EDC1-Supplier B	6.14	6.05	5.5%
	EDC1-Supplier A	5.96	5.96	6.9%
HC	ECD1 Baseline	0.12	0.30	0%
	EDC1-Supplier B	0	0	>99%
	EDC1-Supplier A	0	0	>99%
CO	ECD1 Baseline	1.31	2.10	0%
	EDC1-Supplier B	0.24	0.16	92.4%
	EDC1-Supplier A	0.03	0.21	90.0%

In evaluating the durability and reliability of the filters, filters from supplier B at LACSD initially performed well, but backpressure began to rise on all units equipped with the larger filters within 400 to 500 hours of operation. Inspection of the filter showed that the ceramic trap elements had “shifted” out of the canister on all of the larger units. These systems were replaced or re-canned. Since then, new filters with new banding design have accumulated approximately 1,000 hours of operation and the original filters that were re-canned using new banding design have accumulated approximately 2,500 hours. The filters from supplier B performed well on 1996 vintage and newer diesel engines, but were deemed incompatible with the 1970s vintage Poss diesel engines. The filters from supplier A showed excellent durability and reliability throughout the demonstration period with only one failure on a D9 dozer at LACSD. In this failure, the ceramic filter inside the canning shifted and was broken up, causing excessive backpressure and loss of power.

Although basic DPF performance was validated for use on heavy-duty diesel construction equipment, many challenges still remain with installing and mounting large DPFs on large construction equipment. These challenges are compounded by the fact that higher horsepower engines like those tested in this program required two very large filter sizes to handle the high-volume exhaust flow of the engines.

2.12 Reliability of DPF-Systems: Experience with 6000 Applications of the Swiss Retrofit Fleet (SAE paper no. 2004-01-0076)

In 2000, the occupational health agencies of Switzerland (Suva) declared that DPFs are essential for underground workplaces. The environmental agencies of the Swiss federal government (BUWAL) followed in mid-2002 with the Ordinance on Protecting Air Quality at Construction Sites (BauRLL) all over Switzerland. DPFs were first retrofitted onto large public construction sites, with emphasis on air quality in tunnel projects and their associated labor intensive activities. As of 2003, approximately 6,500 construction equipment have been retrofitted with DPFs. This study was conducted to evaluate the filtration quality of VERT-Test compliant traps in both their new state and after 2,000 operating hours. The report examined trap failures, their causes and prevention based on information from manufacturers, retrofitters, and independent inspections.

The first reliability test was conducted in October 2000, asking the manufacturers and retrofitters for feedback. Failure rates in this first survey were in the 5 to 6 percent range. A new survey was conducted in October 2003, based mainly on information provided by manufacturers and retrofitters on overall failure rates. This later survey showed an annual failure rate is below 2 percent. Causes of failure include: defective canning; material defects; faulty gluing of the segmented filters and other manufacturing defects causing functional deficiencies; customer’s handling accidents; and operational errors such as using high sulfur fuels with catalyzed filters.

The experience with this large retrofitted fleet shows the applicability of DPFs for all types of diesel construction equipment. It also demonstrated that DPFs are technically, operationally, and economically feasible and that there are no major obstacles to large scale retrofitting of DPFs to existing diesel engines.

A database of DPFs verified by VERT for the Swiss diesel retrofit program is available at: http://www.akpf.org/index.html.

2.13 City of Houston Diesel Field Demonstration Project

In order to address the air pollution contribution from each City of Houston department, the City established a comprehensive Emission Reduction Plan (ERP) in June 2000. The main goal of the ERP is to reduce NOx emission by 50 to 75 percent and $PM_{2.5}$ by at least 25 to 33 percent. Under the Diesel Field Demonstration Project a number of diesel emissions control devices were evaluated in the field on various vehicles and equipment, including construction equipment, during the summer of 2000 through the fall of 2001. The goal of the project was to identify retrofit emission control systems that can achieve 75 percent NOx reductions and at least 25 to 33 percent reduction in fine particulates.

Environment Canada performed the gaseous and particulate exhaust emissions testing on the City of Houston fleet vehicles at Ellington Field, Houston, Texas. A total of 29 units were selected to be representative of the fleet, of which 26 were field tested with emissions control devices. In addition to demonstrating the effectiveness of emissions control devices, the program also evaluated various emulsified diesel fuel formulations. Several manufacturers provided various emissions control technologies to demonstrate the effectiveness of these devices to reduce exhaust emissions. Diesel retrofit technologies evaluated included DOCs, passively regenerated DPFs, and SCR systems. With respect to construction equipment, this project evaluated three different retrofit technology options on a 1992 MY Cummins Gradall G3WD 6BTA 5.9L 190 hp: DOC + emulsified diesel fuel, an SCR system, and a combined DPF + SCR system.

After installation, the vehicle was returned to regular service for a period of time advised by the manufacturer to degreen the device. At the end of this period, emissions testing were performed with the device installed. The following is the summary of results from emissions testing with emissions reduction devices installed:

Table 1: Summary of Emission Testing Results

Vehicle	Technology Installed	% NOx Reduction from baseline	% TPM Reduction from baseline
Gradall G3WD	DOC + Emulsified Diesel	34.8	76.3
Gradall G3WD	SCR	78.2	26.7
Gradall G3WD	DPF + SCR	84.0	91.9

More information on this project is available at: http://www.arb.ca.gov/msprog/ordiesel/Documents/houston_demo_project.pdf.

As a result of the field demonstration program described above, SCR was selected as one of the technologies to be used on City fleet equipment. This City of Houston Fleet Retrofit project involves retrofitting 33 rubber tire excavators with SCR and one SCR system was installed on a 2003 model year dump truck. In addition, the City has retrofitted about 30 to 40 nonroad engines such as backhoes and water pumps with DOCs. This program will include emission testing at the University of Houston’s testing facility with chassis dynamometer to quantify the emission reductions achieved with the retrofit technologies. This project is funded by the Texas Council on Environmental Quality (TCEQ) with Texas Emission Reduction

Program (TERP) funds and the Houston-Galveston Area Council with Congestion Mitigation and Air Quality (CMAQ) funds in the amount of $500,000 for the SCR systems.
The vehicles and equipments that were retrofitted include:

- Gradall rubber-tire excavators powered by 1994 to 2000 MY Cummins 5.9L 190 hp engines
- 2003 MY dump truck powered by a Cummins ISC 315 330 hp engine

As of February 18, 2005, all 33 ditch excavators were equipped with an initial design SCR system and the SCR system was to be upgraded to increase the level of emission reduction. The SCR systems that were installed included a DOC and a warning signal to indicate when the ammonia supply was getting low. The SCR system was not verified at the time it was installed on the equipment. However, the Houston program helped to provide data for the eventual ARB verification of the SCR for application on nonroad 1991-1995 Cummins 5.9L from 150-200 hp engines. The SCR systems on the excavators was to be upgraded with a SCR system that will include a hybrid DPF used with ULSD to achieve greater PM emission reduction. The SCR systems have been in operation for up to three years and have reported no major problems. For more information on this project, go to Appendix B of the Final Draft of *Diesel Retrofit Technology and Program Experience* report at:
http://www.epa.gov/cleandiesel/publications.htm.

2.14 New Meadowlands Stadium Project

On June 1, 2009, the U.S. EPA and the New Meadowlands Stadium Company (the Meadowlands Stadium's principal owner) signed a memorandum of understanding that outlines plans to incorporate environmentally-friendly materials and practices into the construction and operation of New Meadowlands Stadium in East Rutherford, NJ. The agreement details strategies to reduce air pollution, conserve water and energy, improve waste management, and reduce the environmental impact of construction. One of the strategies established under the agreement calls for reducing air pollution from diesel construction vehicles by using cleaner diesel fuel, installing emission control devices, and reducing engine idling. Other strategies include: using approximately 40,000 tons of recycled steel to build the stadium and recycling 20,000 tons of steel when Giants Stadium is demolished; installing seating made partially from recycled plastic and scrap iron; building the stadium on a parcel of rehabilitated land; using environmentally-friendly concrete in construction; reducing water consumption and increasing energy efficiency; and providing mass transit options for fans. For more information on EPA's green construction and operations agreements, go to: www.epa.gov/region02/greenteam/.

3.0 NONROAD EQUIPMENT REGULATIONS

3.1 ARB In-Use Off-Road Diesel Vehicles Regulation

On July 26, 2007, the California ARB approved a regulation to reduce emissions from existing off-road diesel vehicles used in California in construction, mining, and other industries. Any person, business, or government agency that owns or operates diesel-powered off-road vehicles in California with engines with maximum power of 25 hp or greater are subject to the regulation. The regulation requires fleets to apply exhaust retrofits, and to accelerate turnover of fleets to newer, cleaner engines. The regulation establishes fleet average emission rates for PM and NOx that decline over time. More information on this regulation is available at: http://arb.ca.gov/msprog/ordiesel/ordiesel.htm.

3.2 New York City Local Law No. 77

New York City Local Law No. 77 was signed into law on December 22, 2003 and requires the phase-in use of ULSD and best available technology (BAT) for emission control in all diesel-powered nonroad vehicles used in city construction projects. It applies to all diesel nonroad vehicles with an engine rated at 50 hp or greater that is owned by, operated by or on behalf of, or leased by a city agency. From December 19, 2005 on, any solicitation for a public works contract less than $2 million must specify that the contractors use Best Available Technology (BAT), but this schedule has been delayed. The Commissioner of the New York City Department of Environmental Protection will update the list of approved technology at least every six months, and includes those technologies verified by EPA or ARB. The requirements of Local Law No. 77 are enforced with penalties for those contractors that violate the provisions of the law, such as civil fine between $1,000 and 10,000 plus twice the amount of money saved by the contractor failing to comply with the requirements. More information on Local Law No. 77 can be found at: http://www.nyccouncil.info/pdf_files/bills/law03077.pdf.

3.3 Cook County, Illinois, Green Construction Ordinance

On May 28, 2009, Cook County, Illinois (greater Chicago), became the first county in the Midwest to adopt a Green Construction Ordinance. The ordinance will require all Cook County contractors working on public construction contracts budgeted at $2 million or more to begin to use ultra-low sulfur diesel fuel for off-road vehicles and equipment immediately and phase-in the use of diesel retrofit technologies on uncontrolled on-road and off-road vehicles and equipment. Beginning in mid-2011, prime contractors and subcontractors must install, at a minimum, Level 2 verified PM retrofits (minimum 50% reduction in diesel PM) on off-road equipment used in these publicly funded projects. Effective January 1, 2014, prime contractors must install Level 3 verified PM retrofits (minimum 85% reduction in diesel PM) on any on-road or off-road engines used in publicly funded projects. Subcontractors have until January 1, 2016 to install Level 3 verified PM retrofits on any on-road or off-road engines used in publicly funded projects. In the Chicago metropolitan area alone, diesel PM is estimated to cause more than 700 premature deaths and more than 17,000 asthma attacks each year. More information on this is available at: http://www.suffredin.org/legislativelibrary/Legislation.asp?LegislationID=475&Library=cook.

3.4 New York State Diesel Retrofit Program

In June 2006, the New York State passed the Diesel Emissions Reduction Act of 2006, requiring state-owned diesel vehicles and those working on state contracts to use ULSD fuel and the "best" diesel retrofit emission control technology to reduce diesel PM emissions. In June 2009, the New York State Environmental Board approved regulations that require all heavy-duty diesel vehicles owned by New York State agencies and authorities and by contractors working on behalf of the state be retrofitted or replaced to decrease diesel PM emissions by December

2010. The regulations also require the use of ULSD fuel in state-owned or contracted heavy-duty vehicles, including on and off-road vehicles. The regulations require application of "best available retrofit technology". Compliance options include replacement of a vehicle with a 2007 or new vehicle that is equipped with a DPF or retrofit of an existing vehicle with the highest level verified PM retrofit technology. More information on this regulation is available at: www.dec.ny.gov/regulations/47297.html.

3.5 New Jersey Diesel Retrofit Program

In 2005, the New Jersey Legislature adopted the Diesel Retrofit Law to clean up emissions from certain on-road, diesel-powered motor vehicles and non-road vehicles/equipment through the use of retrofit emission control technology. The regulation, administered by the New Jersey Department of Environmental Protection (NJDEP), requires publicly-owned off-road vehicles with at least 175 hp to be retrofitted with best available retrofit technology (BART), as determined by NJDEP. More information on this regulation is available at: http://www.stopthesoot.org/retrofit.htm.

4.0 FUNDED PROJECTS

4.1 American Reinvestment and Recovery Act of 2009 (ARRA)

In April 2009, the U.S. EPA began awarding $88 million from the federal stimulus package Diesel Emission Reduction Act (DERA) funds to states for programs to clean up or retrofit diesel engines. Under the American Reinvestment and Recovery Act (ARRA) of 2009 state clean diesel funding program, all 50 states and the District of Columbia received $1.73 million to reduce emissions from diesel vehicles. The following states will use the funding to clean up or retrofit construction equipment:

- Wyoming Department of Environmental Quality received $1.3 million to purchase emission control devices for nonroad construction equipment providing services to the natural gas fields of Sublette County, WY. Nonroad construction engines will be equipped with 50 DOCs and 13 DPFs. More than 25 engines on additional nonroad construction equipment will be upgraded or repowered. More information on this is available at: yosemite.epa.gov/opa/admpress.nsf/6424ac1caa800aab85257359003f5337/28cf704ea636edcf852575e1007097c9!OpenDocument.
- Louisianan, Arkansas, West Virginia, District of Columbia, Delaware, Maryland, Pennsylvania, Virginia, Kansas, Missouri, Nebraska, and Iowa will fund projects that reduce diesel emissions from on-road and off-road equipment through idle reduction technologies, engine upgrades, and replacements, clean fuels, clean diesel emerging technologies.
- City of Charlotte-Mecklenburg County, NC, received $1,116,600 to repower or replace nonroad construction equipment, stationary diesel engines, or highway diesel engines in the 13-county bi-state nonattainment regions for the 2008 ozone standard.
- California Department of Transportation (Caltrans) received $951,431 in funding to install DPFs on 46 Caltrans-owned construction equipment, including crawler tractors, excavators, forklifts, graders, rollers, rubber tire loaders, surfacing equipment, sweepers, scrubbers, tractors, loaders, and backhoes. This equipment will operate throughout California, although

a large proportion will be located in the Los Angeles, San Bernardino, and Riverside Counties as well as the Bay Area.

- Port of Long Beach Diesel Emissions Reduction Project received $4,008,250 in funding to implement a large-scale diesel emission reduction project involving equipment replacements, engine repowers, and/or engine retrofits for 112 pieces of cargo handling equipment including rubber-tired gantry cranes, and two harbor craft currently in operation at the port.
- San Joaquin Valley Unified APCD received $2 million in funding to repower 30 agricultural off-road equipment vehicles with new engines that meet or exceed EPA's Tier 3 emission standards for nonroad diesel engines.
- Montana Department of Environmental Quality, MT received $700,000 to repower four nonroad coal-hauling and dump truck engines owned by Decker Coal Company in Montana. The funding will pay for 75% of the cost of the engine repowers, with Decker Coal Company contributing the remaining 25% of the cost. (yosemite.epa.gov/opa/admpress.nsf/6424ac1caa800aab85257359003f5337/ab5fd776aed9b482852575e100654b3d!OpenDocument)

.

4.2 North Carolina Department of Environment and Natural Resources LEADER Program

The North Carolina Department of Environment and Natural Resources (NC DENR)'s Leading in Early Adoption of Diesel Emission Reductions (LEADER) program provides $750,000 in funding for private and public equipment owners for engine repowers, equipment replacements, or engine upgrade kits. Under the program, the construction equipment must be used in North Carolina and there must be a 50/50 split on the cost share between the grant money and equipment owner for a repower project, and an 80/20 split for an engine upgrade kit.

4.3 Tennessee Department of Transportation Road Construction Diesel Retrofit Project

The Tennessee Department of Transportation (TDOT) provided $800,000 for a grant project aimed at reducing emissions from diesel engines in nonattainment areas of the state. The pilot Road Construction Diesel Retrofit Project seeks to reduce diesel emissions from construction equipment used on federally funded road projects in nine nonattainment counties in the Knoxville and Chattanooga areas. This competitive funding opportunity was available to road construction companies and associated suppliers with current or recently awarded state road construction contracts in these East Tennessee counties.

4.4 Massachusetts Department of Environmental Protection Construction Retrofit Projects

The Massachusetts Department of Protection (MassDEP) awarded three towns in the state with a total of $5,135 to retrofit three municipal construction vehicles. DOCs were installed on three front-end loaders owned by the towns of Bernardston, North Andover, and Wakefield. The funding is part of the state-wide diesel retrofit initiative announced in December 2006, which includes $22.5 million grant to retrofit all school and transit buses in Massachusetts, retrofit off-road engines used in state-funded construction projects, and enforce the state's anti-idling regulation.

4.5 Kentucky Construction Equipment Retrofit Project

On October 8, 2008, Kentucky Governor Steve Beshear (D) announced the approval of $240,000 in Congestion Mitigation and Air Quality (CMAQ) funds for a project to reduce diesel emissions from highway construction equipment. The Diesel Retrofit for Highway Construction Equipment project, administered by the Kentucky Transportation Cabinet, makes retrofit technologies available to construction companies for the purpose of reducing PM emissions from their equipment. Funding for this project was made available on a first-come, first-served basis and recipients were required to provide a 20% match. For more information on this retrofit project, go to: tea21.ky.gov/air_quality_files/cmaqhome.htm.

4.6 West Coast Diesel Emissions Reduction Collaborative Construction Projects

East Side Combined Sewer Overflow Project

The City of Portland's Combined Sewer Overflow (CSO) program is the largest public works project in the history of the State of Oregon, comprising three "Big Pipe" projects: the Columbia Slough Consolidation Conduit; the West Side "Big Pipe"; and the East Side "Big Pipe". The East Side CSO Tunnel or "Big Pipe", to begin in 2006, is the final and largest of the projects in Portland's 20-year program. During this five year construction project, approximately 150 diesel powered vehicles will be used for construction. The proposed project plan will require the use of ULSD in all project vehicles, use equipment that comply with EPA Tier 2 requirements for nonroad engines at a minimum and install best available retrofit emission control devices, such as DPF, DOC or wire mesh flow-through filters. The funding for the fuel premium will be paid by the contractor and ultimately the ratepayers in the city, but funding for retrofitting is requested from other sources to realize the full environmental and public health benefits that are available. The project is scheduled to be completed in 2011. More information on this project is available at: www.portlandonline.com/cso.index.cfm?c=31727.

City of Fresno Wastewater Treatment Facility Retrofit Project

City of Fresno, Fleet Management Division has agreed to participate in a demonstration program to retrofit three pieces of nonroad equipment with a diesel retrofit technology currently verified by both EPA and ARB for onroad applications to reduce emissions of PM, NOx, VOC and CO. The equipment to be retrofitted is currently operated daily at a Wastewater Treatment Plant located in southwestern quadrant of the City of Fresno. The equipment will be retrofitted with a combined lean NOx catalyst/DPF technology that is currently verified by ARB for PM and NOx reductions on a range of on-road diesel engines. This project will demonstrate the viability of a combined PM/NOx emission reduction technology in nonroad engines. The manufacturer of the retrofit technology will conduct all necessary field engineering work and will also be responsible for submitting the progress and final reports. The City of Fresno will make the equipments available as well as collect all necessary maintenance and operational data. More information on this project is available at: www.westcoastdiesel.org/projects.htm.

Washington Clean Construction: Feasibility Demonstration for Retrofit of Non-road Equipment Project

In order to reduce toxic air emissions, the Yakima Regional Clean Air Authority (YRCAA) is participating with six local air authorities, the Washington State Department of Ecology (Ecology), and the American Lung Association in a demonstration project to retrofit nonroad diesel equipments. In coordination with local air authorities, Ecology will implement a state-wide program to reduce emissions from diesel-powered construction equipment. The purpose of this demonstration project is to demonstrate to the public and private fleet owners of nonroad, diesel powered equipment, the feasibility of retrofitting these equipment with DOCs without disrupting fleet operations. Approximately 50 vehicles will be retrofitted with federal funding and in-kind contribution. More information on this project is available at: www.westcoastdiesel.org/projects.htm.

Construction Equipment Retrofit Demonstration Project

The Construction Equipment Retrofit Demonstration Project is a joint effort of the Collaborative, the Sacramento Metropolitan Air Quality Management District (SMAQMD), and a retrofit technology manufacturer to retrofit five pieces of heavy construction equipment with emission-reducing device. The demonstration project will then evaluate the viability of the retrofit technologies to reduce PM and, to the extent feasible, NOx, HC, and CO emissions. This project will be funded through a $211,000 grant from EPA and $14,000 from SMAQMD. The goal of the demonstration project is to install emission control devices to five pieces of construction equipment to reduce annual diesel emissions by more than 85 percent for PM, up to 25 percent for NOx, and up to 90 percent for CO. More information on this project is available at:
http://www.westcoastdiesel.org/grants/files/Construction%20Equipment%20Retrofit%20Fact%20Sheet.pdf.

Oregon Construction Equipment Emissions Reduction Project

The Oregon Environmental Council (OEC) is working with builders, state environmental officials, the City of Portland, and other jurisdictions to reduce construction equipment diesel emissions. Through diesel engine retrofits, cleaner fuels, and idle reduction policies, the project aims to reduce diesel emissions from construction equipment used in the City of Portland by at least 20 percent. After the evaluation of the project results, the project's most efficient methods may be applied to reducing construction equipment emissions along the West Coast. This project is funded through a $26,000 grant from EPA, and $27,000 from OEC. More information on this project is available at:
http://www.westcoastdiesel.org/grants/files/OEC_Construction_Reduction_fact%20sheet.pdf.

5.0 SUMMARY

As shown by the above case studies, experiences with retrofitting construction equipment with emission control devices are growing. The majority of the retrofit experience in construction equipment projects has been focused on demonstrating the feasibility of applying verified, onroad retrofit emissions control technology on construction equipment and quantifying the diesel emission reductions achieved. Many of the projects have been initiated by the state, local and federal agencies to promote interest in retrofitting construction equipment and facilitate other retrofit projects that may build on the successes and challenges learned from previous projects. Much of the experience with construction equipment retrofit projects has been with DOCs. This stems, in part, from the more universal applicability of diesel oxidation catalysts on existing diesel engines compared to other retrofit technology options. Experience to date with DPFs on in-use construction equipment is more limited due to the fact that applications of DPFs involve more engineering constraints with respect to the duty cycles and engine out emission characteristics of diesel engines used in construction equipment applications. Retrofit DPFs also generally require the use of ultra-low sulfur diesel fuel (ULSD). The availability of ultra-low sulfur diesel fuel for nonroad diesel engines will expand significantly as the rollout of ULSD for highway applications expands nationwide in the second half of 2006. Emerging onroad verified retrofit technologies such as actively regenerated DPFs and flow-through particulate filters should also find applications in nonroad diesel engines and provide more options for significant reductions in diesel particulate emissions from construction equipment. Similarly, verified retrofit technologies that provide reductions in NOx emissions such as lean NOx catalysts and SCR systems will also migrate into the nonroad sector and see greater attention on construction equipment in the future. The construction equipment segment requires an expanded range of verified retrofit technologies to provide broader application coverage for the range of engines and equipment that are currently a part of the existing fleet.

There is an increased interest for retrofitting diesel construction equipment, largely due to the availability of more federal, state, and local incentive funds that can be used for these projects. One such funding source is the federal DOT/EPA Congestion Mitigation and Air Quality (CMAQ) Program. Funds from the CMAQ program have been used to pay for onroad diesel retrofit project and now can be used for retrofit projects on nonroad engines used in construction projects in nonattainment or maintenance areas with respect to air quality. The CMAQ funding provides priority for diesel retrofit and other cost effective emission reduction activities, with funding for the overall program of about $1.4 billion per year through 2009. These CMAQ funds are typically controlled at the state and local level, most often by metropolitan planning organizations. Other significant state sources of funding for construction retrofit projects are available in California through ARB's Moyer incentive funding program (see www.arb.ca.gov/msprog/moyer/moyer.htm) and in Texas through the Texas Emission Reduction Plan (see www.tceq.state.tx.us/implementation/air/terp/). Other states are considering similar funding schemes for incentivizing retrofit projects with onroad and offroad diesel engines. Through utilization of the available funding sources and building on the lessons learned from previous projects, retrofit of construction equipment with emission control technology will become more widespread and provide an important tool for reducing emissions from the large number of existing nonroad diesel engines operating in the U.S.