MassCleanDiesel: Clean Markets Program

Round II

Technology Guide

Massachusetts Department of Environmental Protection

April 2014

Contents

Contact Information

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I. Introduction

The Massachusetts Department of Environmental Protection (MassDEP) is accepting grant applications under Round II of the *MassCleanDiesel: Clean Markets Program* to fund technologies to reduce air pollution from diesel engines that service wholesale markets, warehouses, and distribution centers in Massachusetts. Full or partial grants are provided for the purchase and installation of the following three types of diesel emission reduction technologies:

- **Auxiliary Power Units (APUs)**, idle reduction technologies that provide heating, cooling and electricity to Class 8 long-haul trucks, allowing engine owners to turn off the main truck engine during periods of extended idling. Grants for APUs are only available if a retrofit is installed on the vehicle as well.
- **Retrofit Technologies**, pollution control equipment that is installed in the exhaust stream of a diesel engine. Diesel oxidation catalysts (DOCs) and active and passive diesel particulate filters (DPFs) are offered under this program either alone or in conjunction with an APU.
- **Electric Transportation Refrigeration Units (eTRUs)**, electricity-powered TRUs that are attached to semi-stationary or stationary trailers to provide heating and cooling. Grant recipients must scrap their existing diesel TRUs in order to receive an eTRU.

Each diesel emission reduction technology has significant environmental, health, and social benefits. Two technologies—APUs and eTRUs—also have economic benefits. Engine owners need to weigh these factors in making their decision about whether to apply for a technology. This guide is designed to assist in this decision-making process by discussing the various benefits of each technology as well as their operational characteristics and maintenance requirements. Specific vendors and the products they offer are listed at the end of the document.

II. The Benefits

Grant participants can reap a variety of gains with the installation of the technologies offered through the *MassCleanDiesel: Clean Markets Program.*

Economic

Participants who opt for eTRUs and APUs on their respective trailers and trucks will save significant amounts of money in fuel and maintenance costs. APUs shift the energy load of heating, cooling, and electricity from the main engine to the APU, reducing wear on the main engine and significantly lowering fuel consumption.

Table I on the following page shows the benefits of using an APU. In just one year, an engine owner idling approximately 10 hours a day five days a week can save over $8,000 in fuel costs by installing

an APU. Savings in maintenance costs are also significant—up to $600 a year—because the belts in an APU do not have to be changed as frequently as those in the main engine.

APUs are becoming more commonplace in the long-haul trucking industry because vehicle owners have recognized their economic benefits. Participants in the MassCleanDiesel: Clean Markets Program are saving these upfront costs because MassDEP is funding 100% of the cost to acquire and install an APU, as long as the APU is installed in conjunction with a diesel retrofit device.

Table 1. APU Annual Savings

Activity	Main Engine	APU	Savings
Diesel Fuel [1]	$ 10,320	$ 2,270	$ 8,050
Maintenance	$ 1,200	$ 600	$ 600
TOTAL	**$ 11,520**	**$ 2,870**	**$ 8,650**
[1] Main Engine Idling: 1 gal/hr x 2,400 hr/yr x $4.30/gallon			
APU: 0.22 gal/hr x 2,400 hr/yr x $4.30/gallon			

The market price of the APU being provided under this program is currently about $11,180, including installation. The prices of the DOCs offered in the program range from $790 to $2,965, depending on which vendor is supplying the device. *A grantee opting for an APU and a DOC can thus save between $11,970 and $14,145 by participating in the MassCleanDiesel: Clean Markets Program.*

Grantees opting for an APU in combination with a passive or active DPF would realize even more savings. The cost of an installed passive DPF provided under this program ranges from $6,825 to $20,655. A grantee opting for an APU and a passive DPF would therefore save from $18,005 to $31,835. The cost of an installed active DPF provided under this program ranges from $9,825 to $17,200. *The grantee choosing an APU and an active DPF would save between $21,005 and $28,380.*

Similarly, electrification of transportation refrigeration units on truck trailers used for cold storage is a very cost-effective method to reduce diesel emissions. eTRUs provide direct economic benefit by eliminating diesel fuel consumption and shifting the refrigeration power source from a diesel engine to the more economical and efficient electrical power grid. eTRU owners can expect:

- ✓ *Lower Maintenance Costs.* Electric motors have fewer moving parts and therefore require minimal maintenance compared to diesel engines.
- ✓ *Greater Reliability*. New electric motors are designed for years of trouble-free operation.
- ✓ *Lower Energy Costs.* Monthly electricity costs are about one-fourth of current monthly diesel fuel costs.
- ✓ *Reduced Administrative Burden.* Switching to electrically powered units eliminates the need for fuel delivery scheduling and payments.

This program will fund 75% of the cost to replace a diesel-powered TRU with a new electric unit, with only 25% of the total cost borne by the equipment owner. Based on the average cost of the eTRUs supplied in Round I of the Clean Markets Program, grant recipients in Round II can expect to pay from $3,000 to $4,900 (with an average of $4,370) as their share of the total eTRU cost.

After taking this co-pay and the cost to operate the electric unit into account, the fuel savings from switching from a diesel-fueled TRU to an electricity-powered TRU are projected to save grant applicants between $4,600 and $14,000 in the first year of the program. Thereafter, annual fuel savings are expected to range from $9,000 to $18,000 a year after accounting for annual electricity costs. *Lifetime savings, based on a 12-year lifespan of an eTRU and the factors cited above, could range from $104,000 to $215,000 for just one eTRU.*

Table 2. eTRU Annual and Lifetime Savings

Annual Number of Hours Diesel TRU Used	Annual Number of Gallons Used/ Diesel TRU[4]	Annual Diesel Fuel Savings[5]	Annual Electric Costs/ eTRU[6]	Total Saved/Yr (Electric Included)	Average 25% Co-Pay for eTRU[7]	First Year Total Saved (Electric & Co-Pay Included)	Lifetime Total Saved (Electric & Co-Pay Included)[8]
4,320[1]	3,456	$ 14,861	$ 5,832	$ 9,029	$ 4,370	$ 4,659	$ 103,976
6,480[2]	5,184	$ 22,291	$ 8,748	$ 13,543	$ 4,370	$ 9,173	$ 158,148
8,760[3]	7,008	$ 30,134	$ 11,826	$ 18,308	$ 4,370	$ 13,938	$ 215,331

Numbers are based on: [1] 24-hr/day continuous operation for 6 months; [2] 24-hr/day operation for 9 mos.; [3] Year-round 24-hr/day operation; [4] Diesel TRU fuel consumption of 0.8 gallons/hr; [5] Diesel fuel cost of $4.30/gallon; [6] Cost to operate an average 15 kW eTRU (about 56,000 BTUs) at $0.09/kWhr; [7] Average co-pay of grantees in Round I of Clean Markets Program; [8] Average eTRU lifespan of 12 yrs. after considering first-year costs.

These savings will vary of course with the number of hours the diesel unit operated, the cost of the electricity, and how much the new electric unit operates. Some grant recipients in Round I of the Clean Markets Program found that they used the new electric unit more than their old diesel unit because the electric unit polluted less, ran more efficiently, and required less maintenance.

The savings also do not reflect the price to install or upgrade the facility's electric service; if new electrical service is required, the estimated costs range from $1,000 to $5,000 per trailer bay. The lifetime savings potential of the eTRU technology, however, will soon make up for any electricity infrastructure costs that an owner might incur.

In addition to fuel savings and preventing engine wear and tear, diesel emission reduction technologies may produce indirect, long-term economic gains. Employees who are no longer exposed to significant amounts of exhaust pollution may be sick less often, experience improved productivity, and require less investment in health care costs.

Health

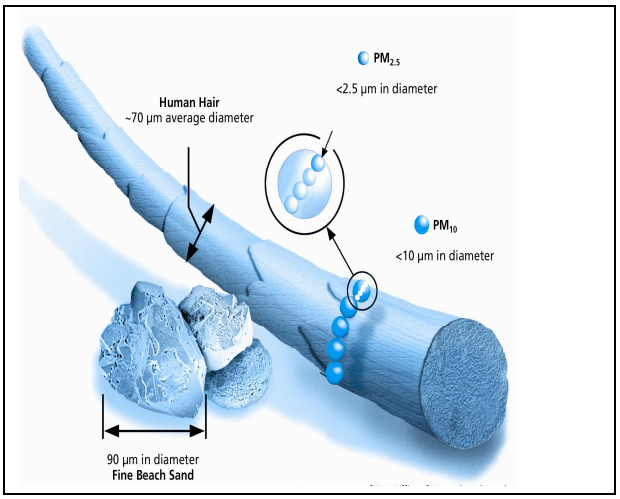
Exposure to diesel exhaust can have serious, detrimental effects on human health. Diesel engines emit both particle and gaseous air pollution. The particle pollution is primarily fine particulate matter (PM) 2.5 micrometers or less in diameter, which is composed of carbon soot and droplets of unburned fuel and lubricating oil. As the diagram shows, this minute size–a typical human hair is over 25 times wider than a $PM_{2.5}$ particle—allows the particles to slip past the body's defenses and lodge deep within the lungs when inhaled. The smallest particles may even enter the bloodstream directly through the lungs.

Short-term exposure to elevated PM levels can aggravate existing lung disease, increase the severity of asthma attacks, coughing, and acute bronchitis, and intensify susceptibility to heart attacks and arrhythmias in people with existing heart disease.

Diesel engines also emit the following gaseous pollutants:

- Carbon monoxide (CO), a colorless, poisonous gas that causes headaches, dizziness, and other flu-like symptoms, at low levels of exposure. Because CO can inhibit oxygen intake, exposure may worsen the condition of those with cardiovascular issues. At moderate concentrations, angina (chest pain), impaired vision, and reduced brain function may result.[1]

Diesel Particulate Matter (PM) Size Compared to Human Hair and Beach Sand



Source: US EPA Office of Research & Development

- Hydrocarbons (HC), exposure to which is associated with chest tightness and shortness of breath. HC contains many toxic compounds, such as benzene and formaldehyde, each of which is designated as a hazardous air pollutant and/or carcinogen and has several wide-ranging health effects. HC and NOx (see below) also react with sunlight and heat to form ground-level ozone, the main component in smog. Short-term exposure to ozone can result in wheezing, throat irritation and coughing.

- Nitrogen oxide (NOx), a gas that at low levels of exposure can cause nausea, irritated eyes and shortness of breath. At high levels of exposure, NOx can lead to swelling of the throat and reduced oxygen intake.

APUs and eTRUs, which greatly or completely eliminate the use of diesel fuel, also reduce carbon dioxide (CO_2), a greenhouse gas which has been associated with climate change.

All technologies included in this program reduce diesel emission exposures to people working or living in close proximity to a diesel vehicle or engine. The health benefits include:

- ✓ *Reduced Health Risks.* With reduced emissions, workers and residents may experience reduced diesel-related sickness and hospitalizations.
- ✓ *Reduced or Eliminated Exhaust Emissions.* Less diesel exhaust means cleaner air for market workers and nearby residents.
- ✓ *Reduced Exhaust Odors.* Less diesel exhaust means less odor, making for a more pleasant environment for market workers and nearby residents.

[1] http://www.epa.gov/iaq/co.html

Finally, eTRUs and APUs are significantly quieter than larger diesel engines, contributing to a healthier working environment.

Environmental

Diesel particles are a major cause of poor visibility in many parts of the United States. Particles in the air scatter and absorb light, reducing the color, clarity and contrast of distant objects. In addition to affecting visibility, diesel particles cause ecosystem damage. Particles are carried over great distances by wind and then settle on ground or water. The effects of this settling include changing the nutrient balance in coastal waters and large river basins and making lakes and streams acidic; damaging sensitive forests and farm crops; depleting soil nutrients; and negatively affecting the diversity of ecosystems.

All technologies offered in the *MassCleanDiesel: Clean Markets Program* reduce diesel particles as well as other pollution that adversely affect the environment, as shown in Table 3:

Table 3. Pollutant Reduction by Technology (At Source)

Device	Pollutants (% Reduction)			
	PM	**NOx**	**HC**	**CO**
eTRU	100%	100%	100%	100%
DOC	20-32%	0%	49-74%	23-50%
DPF (Passive)	85-90%	0%	85%	75%
DPF (Active)	90%	0%	85%	75%

Estimates of APU pollutant reductions depend on the model year (MY) of the engine on the long-haul truck on which the APU is installed and the pollutant that is being addressed. For example, MY1990 through 1993 diesel engines emit more PM than MY 1994 through 2006 diesel engines. Conversely, MY 1991 through 1997 diesel engines emit more NOx than MY 1998 through 2003 engines (in both examples, the relevant model years are 1990 through 2006 because those are the model year engines that can receive retrofits). Generally, an APU that is installed on a truck with an older model year engine will reduce more pollutants than an APU installed on a truck with a newer engine; however, the specific pollutant reductions obtained from an APU cannot be determined without knowing the truck's engine model year.

Social

Businesses that proactively install these technologies demonstrate to the community that they care about their employees and neighbors, demonstrating corporate stewardship and promoting good public relations. If leveraged properly, participation in this program will be seen as an act of social responsibility that may return intangible dividends in the future, including:

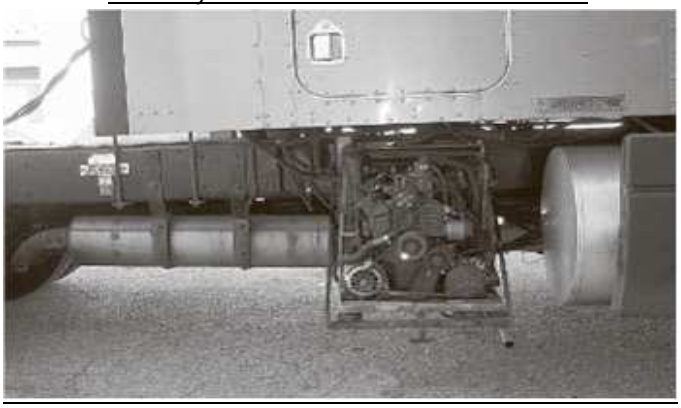
- ✓ *Recognition by the Community.* City or state officials, environmental groups or non-profit organizations may acknowledge your company for taking steps to reduce your environmental burden.
- ✓ *Improved Quality of Life.* Reduced diesel exposure has direct and immediate health and welfare benefits for employees and the communities at large.

III. Auxiliary Power Units (APUs)

Operational Characteristics

As noted earlier, APUs are small engines that provide heating, cooling and electricity to a long-haul truck driver's sleeper cab. With an APU, a long-haul truck driver can enjoy the comforts of home without running the main engine during federally-mandated rest periods or other breaks. All the truck driver needs to do during a rest period is turn off the main engine and then manually set (or pre-set automatically) the APU to turn on. The APU is still a diesel engine but it burns much less fuel and therefore emits far less pollution than the main engine. An APU consumes about 0.22 gallons of fuel per hour whereas a Class 8 truck engine burns approximately one gallon of fuel per hour.

Auxiliary Power Unit Installed on a Truck



Source: Pony Pack, Inc.

MassDEP's approved vendor will only install APUs on Class 8 long-haul trucks with sleeper cabs. APUs also represent the most versatile method of power supply for auxiliary loads. The engine is sized to match the required load.

For this grant program, the eligibility of a truck for an APU depends on the type of retrofit the grant recipient chooses to have installed on the truck. DOCs and DPFs only operate properly on certain model year engines. Grant recipients opting for a DOC must have an engine model year ranging from 1990 to 2006; those opting for a DPF must have an engine manufactured in model years 1994 to 2006. *No trucks with model year 2007 or newer engines are eligible for MassCleanDiesel: Clean Markets Program grants*.

Emission Reductions

In a study conducted by the U.S. Environmental Protection Agency (EPA),[2] results showed that APUs reduced NOx emissions by 89% to 94% and CO_2 by 52% to 81% compared to idling the main engine.

[2] See: "Study of Exhaust Emissions from Idling Heavy-Duty Diesel Trucks and Commercially Available Idle-Reducing Devices", USEPA Technical Report No. EPA-420-R-02-025, October, 2002.

Installation

APUs can either be stand-alone units that provide heated/cooled air directly to the vehicle cab and a place to plug in standard electrical equipment, or they can be integrated with the vehicle's existing HVAC, battery charging and other systems. Installation varies from truck to truck but generally takes from five to 16 hours to install.

Maintenance

APUs require much less maintenance than a main engine that otherwise would idle for hours at a time. APU maintenance intervals are usually around 1,000 hours versus 500 hours for the main engine. Since the engine is much smaller than the main engine, APUs require less oil and fewer filters.

Although APUs only emit a small amount of pollution each hour, the amount becomes significant over 2,400 hours of annual use. Vehicle operators should therefore still try to limit the amount of time they use their APU. For example, when the weather is comfortable, vehicle operators should consider turning their APU off.

Costs

Without grant funding, the cost to purchase and install an APU offered under the MassCleanDiesel: Clean Markets Program is $11,180 for an on-road, Class 8, long-haul truck. Since MassDEP is funding 100% of the APUs (as long as a retrofit device is also installed), there are no upfront costs to the vehicle owner. APU grant recipients will only be responsible for annual maintenance costs—around $600 a year. MassDEP will award grants for 100% of the cost to purchase and install an APU *and* retrofit device. There is no cost-share requirement.

Verification

Only APU technologies verified under EPA's SmartWay Program are eligible for funding under MassDEP's program. SmartWay verifies technologies that have been evaluated to reduce fuel and emissions for use on trucks and locomotives. This list can be viewed at: http://www.epa.gov/smartway/forpartners/technology.htm

IV. Electric Transportation Refrigeration Units (eTRUs)

Operational Characteristics

A transportation refrigeration unit (TRU) is a compact refrigeration system that is installed on a mobile or stationary trailer to cool the trailer's interior for storage and/or transport of perishable goods (the Clean Markets Program is only providing eTRUs for stationary and semi-stationary trailers). Most TRUs are powered by small diesel engines that constantly run to keep temperatures in the trailer at the

Electric TRU and Power Supply

Source: M.J. Bradley & Associates, LLC

desired set-point. Over the course of a year, a diesel TRU that runs continuously may consume as much as 7,000 gallons of diesel fuel and emit a significant amount of diesel pollutants. An electric TRU or eTRU is plugged into a facility's on-site electrical infrastructure, thereby eliminating the use of diesel fuel.

Emission Reductions

eTRUs have zero emissions, thereby reducing PM, NOx, HC, and CO by 100%. Eliminating these pollutants at the source provides a better working environment for workers and local residents. The power plant generating the electricity for the eTRU still emits these pollutants but at a much lower rate.

Installation

An eTRU is designed to be the same size as the existing diesel TRU. Installation is straightforward and requires very little or no modification to the trailer. The diesel unit is removed and a new high efficiency electric unit is installed. As its name suggests, eTRUs require access to electrical infrastructure and service. Participating TRU owners are responsible for arranging appropriate stationary power infrastructure, including completing any needed upgrades to their facility's existing electrical system. (Electricity supply installation or upgrade costs are not funded by this grant program.) Each eTRU will require a 480 VAC/3-phase/30 amp or a 240 VAC/3-phase/60 amp outlet. Electrical infrastructure improvements are estimated to cost between $1,000 - $5,000 per bay, depending on existing electrical service and the extent to which new circuits need to be wired. Factors influencing infrastructure costs include:

- The number of eTRUs to be installed (each eTRU consumes ~12 kWh);
- The availability of excess electrical capacity at the facility;
- The method of providing electrical service to the eTRU (running power supply cord over the trailer to the eTRU vs. installing permanent power supply at the eTRU end of the trailer with buried conduit); and,
- The location of the electrical service relative to the eTRU (i.e., distance necessary to install electrical service).

Maintenance

The electric motors of eTRUs are designed for years of trouble-free operation. The eTRU system requires very little maintenance, with only a one-hour inspection service annually. Recommended parts to inspect include the valve pressure, refrigerant charge, moisture level, voltage, amp readings and pressure wash coils.

Costs

The *estimated* cost provided by pre-qualified vendors in this program to purchase and install an eTRU ranges from $10,710 to $24,445, depending on the vendor and specifics of the technology.

MassDEP will fund a maximum of 75% of the cost to purchase and install an eTRU. The vehicle owner would be responsible for funding the remaining 25% of the cost plus the installation of a new or upgraded existing electrical supply.

V. Retrofit Technologies

Retrofits refer to after-treatment devices that are installed downstream from a diesel engine's exhaust manifold. This program will fund one diesel oxidation catalyst (DOC), active diesel particulate filter (DPF), or passive DPF per vehicle (only one device may be installed on an eligible vehicle). Vehicle owners can apply for funding for either a retrofit device alone or in conjunction with an APU.

This grant program focuses on engine model year 2006 and older heavy-duty short and long haul trucks serving wholesale markets, warehouses, and distribution centers in Massachusetts. Starting in model year 2007, all trucks manufactured for use on public roadways were required to be equipped with a DPF; *2007 and newer engines are therefore ineligible for retrofits*.

Verification

EPA and the California Air Resources Board (CARB) have put the retrofit devices through rigorous in-use and laboratory tests to ensure proper operation in the field, emission reduction performance, and durability so that consumers are assured of receiving the actual benefits claimed by the manufacturer. All retrofit devices funded through this program have been verified by EPA, CARB, or both. EPA's verification website is: http://epa.gov/cleandiesel/verification/verif-list.htm#retrofit. CARB's verification website is: http://www.arb.ca.gov/diesel/verdev/vt/cvt.htm.

A. Diesel Oxidation Catalysts

Operational Characteristics

A DOC is comprised of a stainless steel canister containing a honeycomb structure coated with a precious metal catalyst such as platinum or palladium. As exhaust flows through the DOC, the catalyst converts some of the unburned PM, HC, and CO into relatively benign by-products—mostly water and carbon dioxide.

Diesel Oxidation Catalyst

Source: Cummins Emission Solutions

Emission Reductions

The DOCs offered in the MassCleanDiesel: Clean Markets Program can reduce PM by up to 30%, HC by up to 74%, and CO by up to 50%.

Installation

DOCs are installed in the exhaust stream of a vehicle. Typically DOCs are installed as direct replacements for the existing muffler, although in some cases they can be installed in series with the muffler. When installed, a DOC resembles a standard exhaust muffler, although a DOC may weigh slightly more due to the catalyst substrate. Installation time typically ranges from one to two hours.

Maintenance

DOCs require virtually no on-going maintenance and typically last a minimum of six years.

Costs

Installed DOCs offered in this program range from an estimated $790 to $2,965. Under this program, MassDEP will fund 100% of the cost to purchase and install a DOC, either alone or in conjunction with an APU. There are no cost-share requirements.

Installed Diesel Oxidation Catalyst

Source: MassDEP

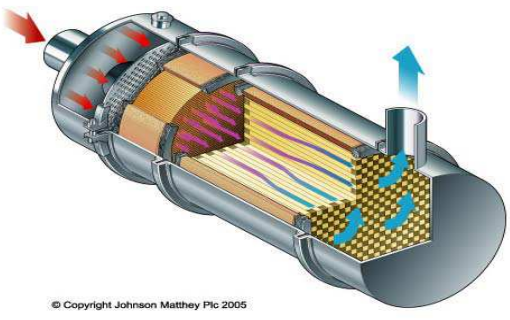
B. Diesel Particulate Filters (DPFs)

Operational Characteristics

A DPF can be either passive (working with the heat in the engine exhaust) or active (using an additional component to add energy to the exhaust to increase temperature). Both systems combine an oxidation catalyst with a porous ceramic, sintered metal, or silicon carbide filter in a metal container similar to an exhaust muffler. Gaseous engine exhaust passes through the porous walls of the filter section, while particles, both solid and liquid, are trapped on the filter walls. The filter bed is heated by either exhaust heat or some other heating mechanism, causing an oxidation reaction between the catalytic coating and captured particles.

Once the filter media become saturated, the DPF will initiate a regeneration process. In this process, unburned fuel vapor and CO are oxidized and converted into relatively benign by-products.

Diesel Particulate Filter

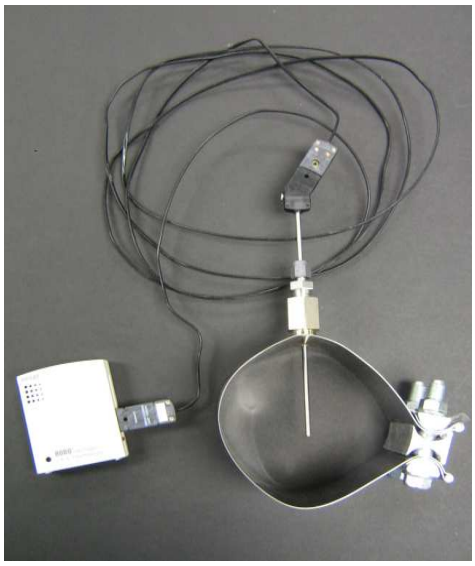


Source: Cummins Emission Solutions

Passive DPFs

Passive DPFs use exhaust heat to regenerate the filter. Therefore they require a *minimum exhaust temperature* of 240℃ to 290℃ for about 35% of total engine operating time in order to trigger filter regeneration. If you decide you want a passive DPF, your vendor will need to install a temporary exhaust temperature data-logging device, shown right, on the vehicle to track its exhaust temperature over a week of typical operation. This temperature data will allow the vendor to determine whether a passive DPF is compatible with the way your vehicle is operated. If it is determined that a passive filter will not work in your application, an active DPF could be used. You could also install a DOC.

Exhaust Temperature Data-Logging Array



Source: MJ Bradley & Assoc., LLC

Active DPFs

Active DPFs use heat from other sources (typically fuel or electricity) to regenerate the filter bed; therefore they do not have any minimum exhaust temperature restrictions. Specific to this program, only one electrically regenerated DPF is offered, the Clean Diesel Technologies, Inc. Purifilter Plus. The CDTi Purifilter Plus incorporates an electric heating element into the filter. When parked at a central location, the unit is hooked up to an electrical panel which turns on the heating element and blows hot air over the filter bed, causing oxidation of collected soot.

Clean Diesel Technologies, Inc, Purifilter Plus™ Active DPF
(External Plug-in Regeneration Panel Not Shown)

Full Onboard Truck DPF Assembly

Inlet Section Electric Heating

Inlet Section Detail

Source: Clean Diesel Technologies, Inc.

Regeneration events for the active DPF must be performed while the vehicle engine is turned off. For an electric DPF to actively regenerate, it must be plugged into either a 240V or 480V AC power source. A regeneration panel is required that supplies the 240/480 voltage to the filter at a metered rate. The vendor or an electrical contractor will need to supply 240/480V AC power to the regeneration panel. Usually a cab-mounted indicator light will illuminate when a regeneration event is required; however, the manufacturer recommends proactive daily connection to the regeneration panel to minimize exhaust backpressure. The regeneration event usually takes two to four hours and requires that the vehicle remain inactive until complete.

Emission Reductions

Both passive and active DPFs achieve significant emission reductions. The passive DPFs offered under the MassCleanDiesel: Clean Markets Program reduce PM emissions by 85% or more, HC by 85%, and CO by 75%. The active DPF offered under this program reduces PM by 90%, HC by 85%, and CO by 75%.

Installation

DPFs are slightly larger than the original muffler and weigh significantly more due to the filter substrate. Additional or more robust mounting hardware is required, and will be provided by the vendor. For passive DPFs, installation time typically ranges from six to eight hours per DPF.
For active DPFs, installation requires at least 10 hours; this includes installation of the filter device and the electric regeneration panel. This installation time does not include electrical infrastructure upgrades necessary to bring power to the electrical regeneration panel.

Installed Passive DPF

Source: US EPA

Maintenance and Filter Cleaning

Installed devices typically last at least six years. DPF core elements require cleaning once every 12 to 24 months, depending on vehicle usage rate and engine condition. Cleaning is necessary to remove ash that builds up in the filter over time. Without periodic cleaning, backpressure will build up in the exhaust system, affecting engine performance. The DPF filter element must be removed from the vehicle to be cleaned.

As shown on the next page, a backpressure monitoring system will be installed in the engine compartment and will indicate when maintenance is required. The monitoring system will activate a maintenance light when the backpressure rises above a certain threshold. The monitoring system will require a connection to the vehicle's 12/24 volt power system.

Filter cleaning requires a special machine and can often be done at a service facility for a fee of $200 to $400 per filter (some vendors can provide this service). The devices approved for this program are designed with a removable filter section connected to inlet and outlet sections with band clamps for easy removal for cleaning. This can be done in as little as half an hour. Typically, filter suppliers will swap filter sections upon removal to minimize vehicle down time.

DPF Backpressure Monitoring System

Source: MassDEP

Costs

The estimated cost provided by approved vendors in this grant program to data log, purchase and install a passive DPF ranges from $6,825 to $20,655. The estimated cost provided by approved vendors in this grant program to data log, purchase and install an active DPF ranges from $9,825 to $17,200. A regeneration panel must be purchased as well for the active DPF.

VI. Technology Manufacturers and Vendor Suppliers

These tables list the vendors that are providing the technologies offered in this grant program. ***Prices are estimated and may vary due to additional parts, labor, or travel charges****. Prices are also subject to change at the time of contract negotiations with vendors.*

APUs (100% Funded; Must Have DOC or DPF too)

Vendor	Manufacturer	Product	Services Provided	Rating	Estimated Total Cost
NEDDA	Carrier	ComfortPro PC6022	Heating/Cooling/Power	12,000 BTU	$11,180
Shuster	Pending	Pending	Pending	Pending	Pending

NEDDA = New England Detroit Diesel Allison

eTRUs (75% Funded)

Vendor	Manufacturer	Product	Rating	Single/Multi-Temperature	Estimated Total Cost
NEDDA	Carrier	Vector 8100	60,000 BTU	Single	$19,045
Zanotti East	Zanotti	EFZ520	24,000 BTU	Both	$22,445
Zanotti East	Zanotti	EFZ 530	30,000 BTU	Both	$24,445
Zanotti East	Zanotti	MAS340	40-55,000 BTU	Both	$12,155
Zanotti East	Zanotti	PAS340	50-68,000 BTU	Both	$18,450
Zanotti East	Zanotti	BAS340	50-68,000 BTU	Both	$14,160
Zanotti East	Zanotti	PAS221	20-35,000 BTU	Both	$10,710

DOCs (100% Funded, Either Alone or with APU)

Vendor	Manufacturer	Product	% PM Reduction	Estimated Total Cost
Southworth-Milton*	Donaldson	Series 6100	20-26	$2,690
NEDDA	Donaldson	Series 6400	28	$2,410
NEDDA	Donaldson	Series 6100	20-26	$2,705
Shuster	CDTi **	AZ25 Purimuffler	20	$2,710
Ward Clean Air	CDTi	AZ25 thru AZ31 Purifiers	20	$ 790 – $2,565
Ward Clean Air	CDTi	AZ25 thru AZ31 Purimufflers	20	$1,260 - $2,965

* Southworth-Milton **CDTi = Clean Diesel Technologies, Inc. (formerly Engine Control Systems)

DPFs (100% Funded)

Vendor	Manufacturer	Product	Type	% PM Reduction	Estimated Total Cost
Shuster	CDTi	SC17 Purifilter	Passive	90	$ 6,825
NEDDA	Donaldson	LNF	Passive	85	$11,695 - $20,655
NEDDA	Donaldson	LXF	Passive	85	$14,430 - $20,655
Ward Clean Air	CDTi	SC06 Purifilter – SC28 Purifilter	Passive	90	$ 6,870 - $12,640
Ward Clean Air	CDTi	SCP06 Purifilter Plus - SCP28 Purifilter Plus	Active	90	$ 9,825 - $17,200