

Retrofit Application Engineering

Manufacturers of Emission Controls Association

*Southeast Diesel Collaborative
Third Annual Partners Meeting
June 25, 2008*



Application Engineering Process

- Opportunity definition
 - Information profile/documentation
- Control technology assessment
 - Verification review
 - BACT review
 - Technology options
- Exhaust temperature/duty cycle
 - Datalogging
 - Analysis/feedback
- Control technology sales/application
 - Product selection/supply
 - Installation/maintenance



Opportunity Definition

- Fleet Analysis
 - Engine/vehicle/MY
 - Engine type/configuration
 - Exhaust system details
 - Mounting hardware
- Wrong information = wrong parts

Emissions System Design Information Profile V02

Manufacturer Information	Manufacturer Name			
	Address			
	City	State	Phone #	Zip
	Contact Name		E-mail	
Customer Information	Company/Client			
	Address			
	City	State	Phone #	Zip
	Total # of Vehicles in Fleet		Total # of Items Specifications	
Vehicle Information	Vehicle Make		Year	
	Vehicle Manufacturer		VIN #	
	Model		Vehicle #	
	Component/Option			
Engine Information	Manufacturer		Turbocharged	
	Engine Model		Engine Family #	
	Year		Exhaust Flow (Rated Power)	
	Displacement (liters)		Horsepower (HP)	
	Rated Power (kW)		Rated at 4000 RPM	
	Component/Option			
Exhaust System	CEM Number (PM)		Inlet Diameter	
	Inlet Inside Dia (in)		Outlet Diameter	
	Inlet Outside Dia (in)		Inlet Inside Dia (in)	
	Inlet Inside Length (in)		Inlet Outside Dia (in)	
Part Information	Part Number			
	Part Name			
Description of Vehicle	Primary Use			
	% Operating at 20-25 mph		Average Speed (mph)	
	% Operating at 26-35 mph		% of Maximum GVW	
	% of Maximum GVW		Percent Total GVW	
	Date of Last 15mg check		PTC (Lbs/HP-hr @ 2000 RPM)	
	Comments			



Emissions Technology Assessment

- Verification review
 - EPA listed
(epa.gov/otaq/retrofit/verif-list.htm)
 - % Reductions of PM, NOx, HC, CO
 - CARB listed
(arb.ca.gov/diesel/verdev/verdev.htm)
 - Level 3 (≥ 85% PM reduction)
 - Level 2 (≥ 50% PM reduction)
 - Level 1 (≥ 25% PM reduction)



Address: http://www.epa.gov/otaq/retrofit/retroverthelist.htm

U.S. Environmental Protection Agency

Voluntary Diesel Retrofit Program

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EPA Home | Transportation and Air Quality | Voluntary Diesel Retrofit | Technology | Verified Products

Verified Products

Verified Technology List

This table shows all the diesel retrofit products that have been approved for use in engine retrofit programs. Select the manufacturer link to learn more about the retrofit kit and its potential compatibility issues. The table shows the percent reduction (of verified or tested levels) that EPA will recognize for emission reductions within state air quality plans. (Retrofit programs leading to air quality plan credits must be approved in advance.)

Key Topics:
[Technology](#)
[Verification Process](#)
[Testing Protocols](#)
[In-use Testing](#)
[Technical Summary](#)
[Verified Products](#)
[Cost Survey](#)

Manuf.	Technology	Applicability	Reductions (%)			
			PM	CO	NOx	HC
Caterpillar, Inc.	Catalyzed Converter/Muffler (CCM)	Highway, heavy-heavy and medium-heavy duty, 4-cycle, non-EGR, model year 1990 - 2003, turbocharged or naturally aspirated	20	20	na	40
Clean Diesel Technologies, Inc.	Platinum Plus Purifier System (fuel borne catalyst plus DOC)	Highway, medium-heavy and heavy-heavy duty, 4 cycle, model year 1998 - 2003, turbocharged or naturally aspirated	25 to 50	16 to 50	0 to 5	40 to 50
Clean Diesel Technologies, Inc.	Platinum Plus Fuel Borne Catalyst/Catalyzed Wire Mesh Filter (FBC/CWMF) System	Highway, medium-heavy duty, 4 cycle, model year 1991 - 2003, non-EGR, turbocharged or naturally aspirated	55 to 76*	50 to 66*	0 to 9*	75 to 88*
Donaldson	Series 6000 DOC & Spiracle (closed crankcase filtration system)	Highway, heavy-heavy and medium-heavy duty, 4 cycle, non-EGR, model year 1991 - 2003, turbocharged or naturally aspirated	25 to 33*	13 to 23	n/a	50 to 52
Donaldson	Series 6100 DOC	Highway, heavy-heavy and medium-heavy duty, 4 cycle, non-EGR, model year 1991 - 2003, turbocharged or naturally aspirated	20 to 26	36 to 41	n/a	49 to 66

gov/diesel/verdev/level2/level2.htm

Skip to: Content | Footer | [Accessibility](#) | [A-Z Index](#) | Search

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VERIFICATION PROCEDURE - LEVEL 2

This page last reviewed January 3, 2008.

Level 2

LEVEL 2 verification is for those technologies achieving at least 50 percent or greater reduction in particulate matter. If the technology also includes NOx reduction, it will be stated in the description. Please read the executive order(s) below which provide additional information on the applicability of the device for your particular engine. Click on the link below each system for a list of engine families for which devices have been approved (engine series names are provided for reference in most cases). For more detailed information or to purchase the device, please contact the device manufacturer directly. New information will be posted as additional systems are verified. Please check periodically for updates.

- The ARB has verified the [Donaldson Company, Inc.](#) DFM diesel multi-stage filter (DMF) system with / without the Donaldson Spiracle closed crankcase filtration system for 1991 through 2002 diesel engines used in on-road applications operating on ultra low sulfur diesel fuel. The DFM DMF system with / without the Donaldson Spiracle closed crankcase filtration system uses a multi-stage flow through filter with an optional closed crankcase filtration system to achieve a 50 percent reduction in particulate matter emissions qualifying it for a Level 2 verification. Specific engine families and conditions for which the DFM DMF system with / without the Donaldson Spiracle closed crankcase filtration system has been approved may be found in the Executive Order and attachment below.

December 16, 2005	Executive Order DE-05-012	Attachment
December 16, 2005	Executive Order DE-05-013	Attachment

Tailpipe PM Levels On-road

Older engines are higher polluters

Model Year	PM Reg.(g/bhp-hr)	Retrofit Option
Pre-1988	Unregulated (~1.0)	Level 1?
1988-1990	0.60	Level 1
1991-1993	0.25	Level 1,2
1994-2006	0.10	Level 1,2,3
2007+	0.01	OE installed



Tailpipe PM Levels Off-road 300-600 hp

Older engines are higher polluters

Model Year	PM Reg.(g/bhp-hr)	Retrofit Option
Pre-1996	Unregulated (~1.0)	Level 1?
Tier 1 1996-2000	0.40	Level 1, (2,3?)
Tier 2 2001-2005	0.15	Level 1,2 (3?)
Tier 3 2006-2010	0.15	Level 1,2,3
Tier 4 2011	0.015	OE installed



Emissions Technology Assessment

- Best Available Control Technology (BACT)
 - Highest level PM reduction technology (Level 3, 2, or 1) which is verified for specific engine families and operating conditions
- Must start with Level 3
 - Default to Level 2 or 1 when needed



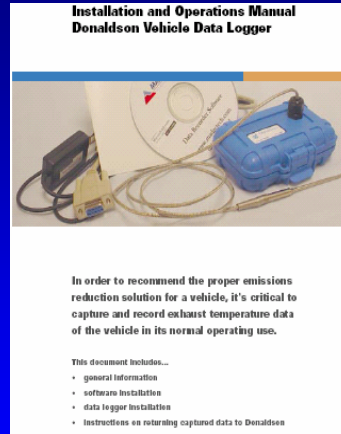
Temperature Profile

- Exhaust temperature/duty cycle requirements
 - Match technology level to engine/vehicle operation
 - Duty cycle dominant
 - Particular engine, ambient temps play smaller role
 - Determine data-logging need
 - Representative sample of engines
 - Coldest applications
 - I.E. short, slow, flat routes; high idle



Exhaust Temperature/Duty Cycle

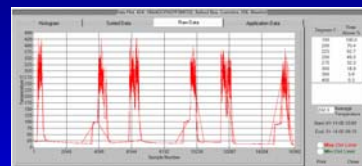
- Temperature profile
 - Data-logger kit
 - Hardware
 - Installation/operations manual
 - Software
 - Instructions/data form
- Complete data-logging
 - Data taken and provided to control technology supplier



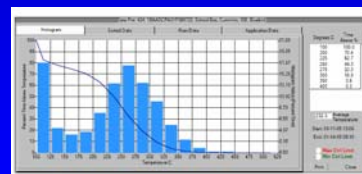
Exhaust Temperature/Duty Cycle

- Data Analysis
 - Data imported into supplier database for analysis and storage
 - Analysis/assessment for proper temperature criteria
- Feedback response documented to customer

Raw Temperature Data



Temperature Plot



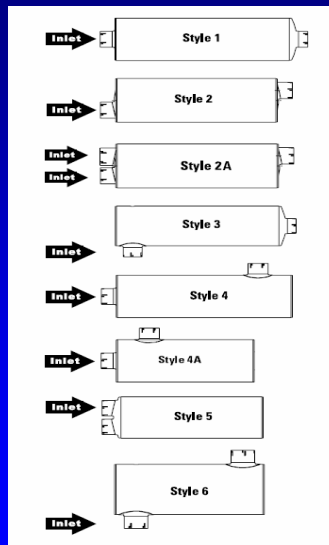
Emissions Technology Application

- Product selection
 - Sales/application literature
 - Engine HP
 - Exhaust flow
 - Muffler configuration
 - Inlet/outlet size

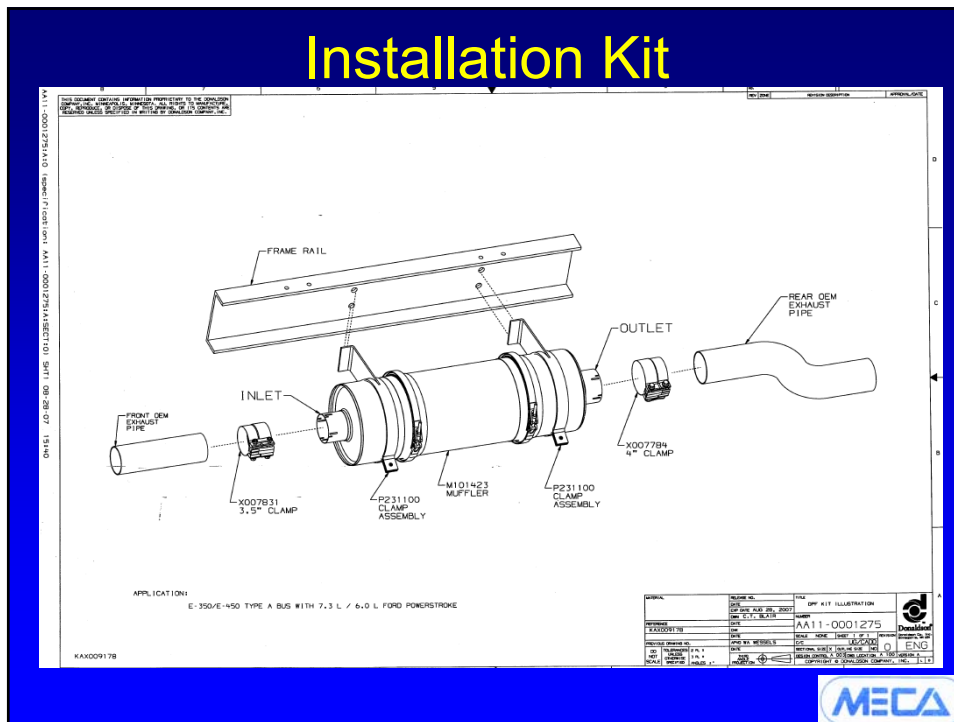
DPF Muffler Kits				
Inlet I.D.	Outlet I.D.	Body Length	Body Dia.	Kit No.
< 1450 CFM (~250 HP)				
Style 1				
3.0"	3.0"	30.0"	10.0"	X009223
3.5"	4.0"	30.0"	10.0"	X009178
< 1700 CFM (~300 HP)				
Style 1				
4.0"	4.0"	36.0"	11.0"	X007858
4.0"	4.0"	36.0"	11.0"	X009132
4.0"	5.0"	36.0"	11.0"	X007862
5.0"	5.0"	28.0"	11.0"	X007933
5.0"	5.0"	36.0"	11.0"	X007860
Style 2				
3.5"	4.0"	36.0"	11.0"	X007986
4.0"	4.0"	36.0"	11.0"	X007930
5.0"	5.0"	28.0"	11.0"	X009286
5.0"	5.0"	36.0"	11.0"	X009045
Style 3				
4.0"	4.0"	36.0"	11.0"	X007864
4.0"	5.0"	36.0"	11.0"	X007866
5.0"	5.0"	36.0"	11.0"	X009046
Style 4				
3.5"	4.0"	36.0"	11.0"	X007998
4.0"	4.0"	36.0"	11.0"	X007880
4.0"	4.0"	36.0"	11.0"	X007991
5.0"	5.0"	36.0"	11.0"	X009244
Style 6				
5.0"	5.0"	36.0"	11.0"	X009239



Muffler Styles



Installation Kit



Emissions Technology Operation

- Installation/maintenance
 - Owner's manual
Installation, warranty and maintenance procedures
- Application documentation files
 - Specific control technology match to engine/vehicle application



Summary

- Complete fleet analysis
- Tailpipe emissions (MY) determine options
- Verified products for grant funded projects
- Exhaust temperature profile needed for Level 2&3
- Engine HP, flow needed for sizing
- Engine & exhaust configuration needed for parts selection

