

# Retrofit Application Engineering

Manufacturers of Emission Controls Association

*Southeast Diesel Collaborative  
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# Application Engineering Process

- Fleet analysis
- Verified products
- Install & later remove data loggers (DPF)
- Determine technology
- Specify parts
- Manage installation
- Warranty information complete
- Customer training & follow up

# Opportunity Definition

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

*Emissions Systems Design*      *Information Profile*  
V2.2

Section One	<b>Distributor Information</b>			
	Distributor Name			
	Address			
	City		State	Zip
	Contact Name		Phone #	
	Fax #		Email	
Section Two	<b>Customer Information</b>			
	Company/Customer			
	Address			
	City		State	Zip
Total # Vehicles in Fleet		Total w/ Same Specifications		
Section Three	<b>Vehicle Information</b>			
	Vehicle Type		Year	
	Vehicle Manufacturer		Vin #	
	Model		Vehicle #	
Comments/Other				
Section Four	<b>Engine Information</b>			
	Manufacturer		Turbocharged	
	Series/Model		Engine Family #	
	Year		Exhaust Flow (Rated Power)	
	Displacement (liters)		Miles on Engine	
	Rated RPM		Date of Last Engine Rebuild	
	Rated Power (hp)			
	Comments/Other			
Section Five	<b>Exhaust System</b>			
	OEM Muffler P/N		Inlet Orientation	
	Muffler Body Shape		Outlet Orientation	
	Muffler Body Dia (in)		Muffler Inlet Tube Dia (in)	
	Muffler Body Length (in)		Muffler Outlet Tube Dia (in)	
Section Six	<b>Fuel Information</b>			
	Max. Sulfur (PPM)			
Section Seven	<b>Description of Vehicle</b>			
	Primary Use			
	% Interstate (> 55 mph)		Average Speed (mph)	
	% Secondary Rd (30-55 mph)		Gross Vehicle Weight (GVW)	
	% Urban (<30 mph)		% of Maximum GVW	
	% Vehicle is working		Power Take Off (Y/N)	
	Daily Idle Time (hrs)		PTO Usage per Day (hrs)	
	Comments			



# Emissions Technology Assessment

- Verification review
  - EPA listed
    - ([epa.gov/otaq/retrofit/verif-list.htm](http://epa.gov/otaq/retrofit/verif-list.htm))
      - % Reductions of PM, NO<sub>x</sub>, HC, CO
  - CARB listed
    - ([arb.ca.gov/diesel/verdev/verdev.htm](http://arb.ca.gov/diesel/verdev/verdev.htm))
      - Level 3 (≥ 85% PM reduction)
      - Level 2 (≥ 50% PM reduction)
      - Level 1 (≥ 25% PM reduction)



# Voluntary Diesel Retrofit Program

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## 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](#)
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  - [Testing Protocols](#)
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Verified Retrofit Technologies							
Manuf.	Technology	Applicability	Reductions (%)				
			PM	CO	NOx	HC	
<a href="#">Caterpillar, Inc.</a>	Catalyzed Converter/Muffler (CCM)	Highway, heavy-heavy and medium-heavy duty, 4-cycle, non-EGR, model year 1998 - 2003, turbocharged or naturally aspirated	20	20	na	40	
<a href="#">Clean Diesel Technologies, Inc.</a> 	Platinum Plus Purifier System (fuel borne catalyst plus DOC)	Highway, medium-heavy and heavy-heavy duty, 4 cycle, model year 1988 - 2003, turbocharged or naturally aspirated	25 to 50	16 to 50	0 to 5	40 to 50	
<a href="#">Clean Diesel Technologies, Inc.</a> 	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 89*	
<a href="#">Donaldson</a> 	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 <sup>a</sup>	13 to 23	n/a	50 to 52	
<a href="#">Donaldson</a> 	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	38 to 41	n/a	49 to 66	
<a href="#">Donaldson</a>	Series 6100 DOC & Spiracle (closed crankcase	Highway, heavy-heavy and medium-heavy duty, 4 cycle, non-EGR, model year					

**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?)
<u>Tier 3 2006-2010</u>	<u>0.15</u>	<u>Level 1,2,3</u>
Tier 4 2011	0.015	OE installed

# Emissions Technology Assessment

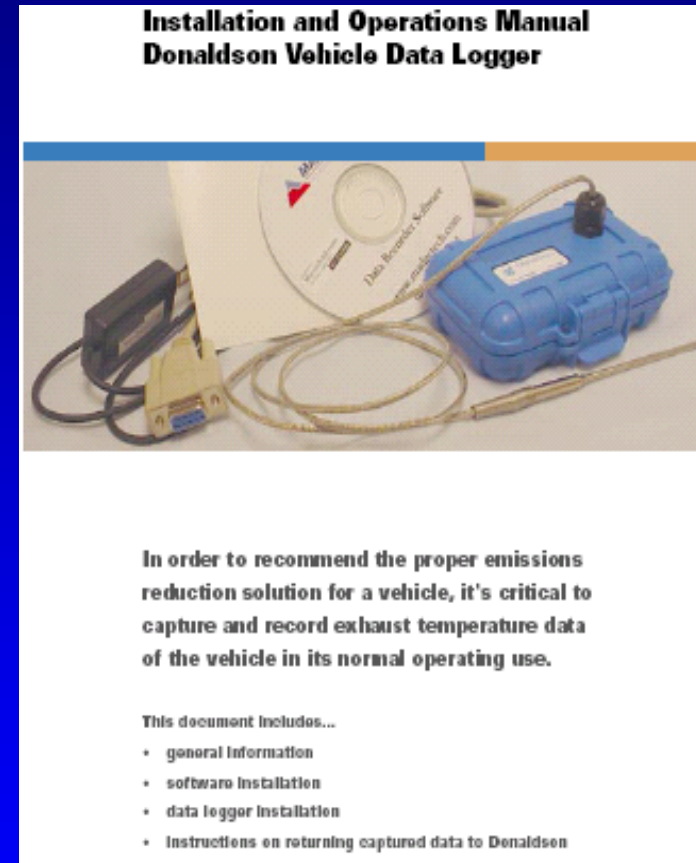
- Level 1 25-49% PM reduction
- Level 2 50-84% PM reduction
- Level 3 85+% PM reduction
- Best Available Control Technology (BACT) required in some states or programs

# 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

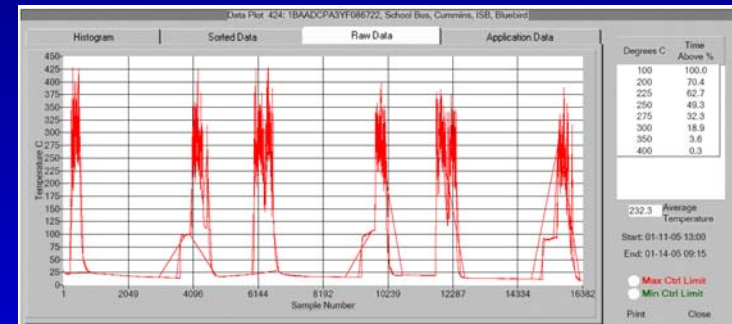
- Temperature profile
  - Data-logger kit
    - Hardware
    - Installation/operations manual
    - Software
    - Instructions/data form
- Complete data-logging
  - Data taken and provided to control technology supplier



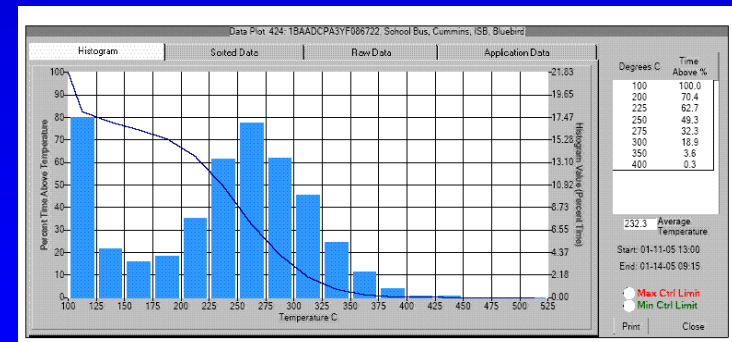
# Exhaust Temperature/Duty Cycle

- 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



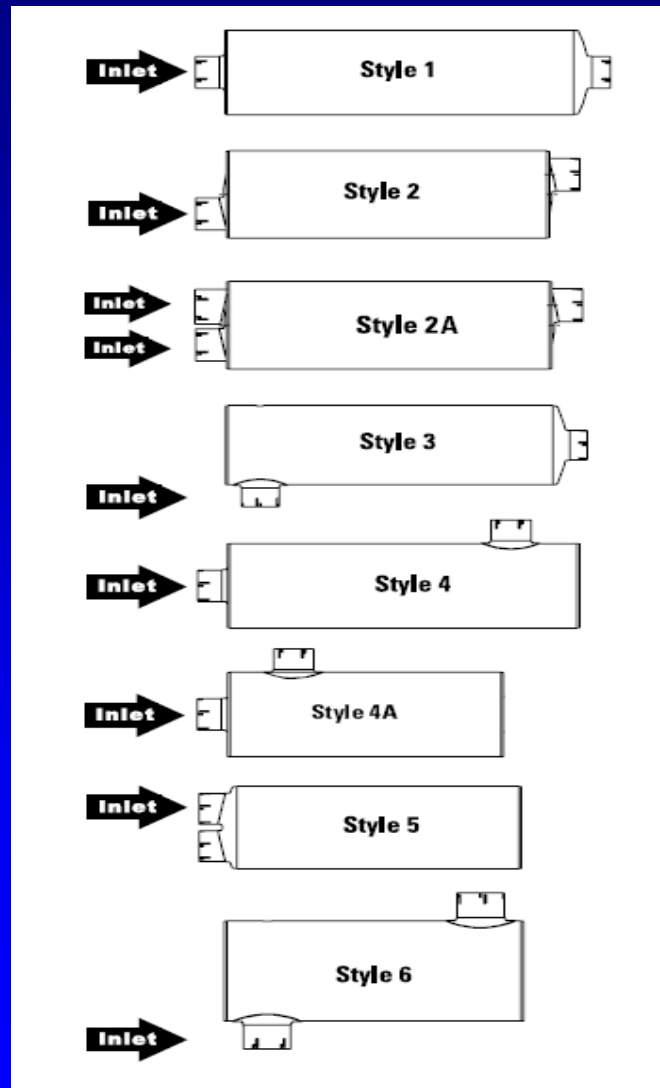
# Emissions Technology Application

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

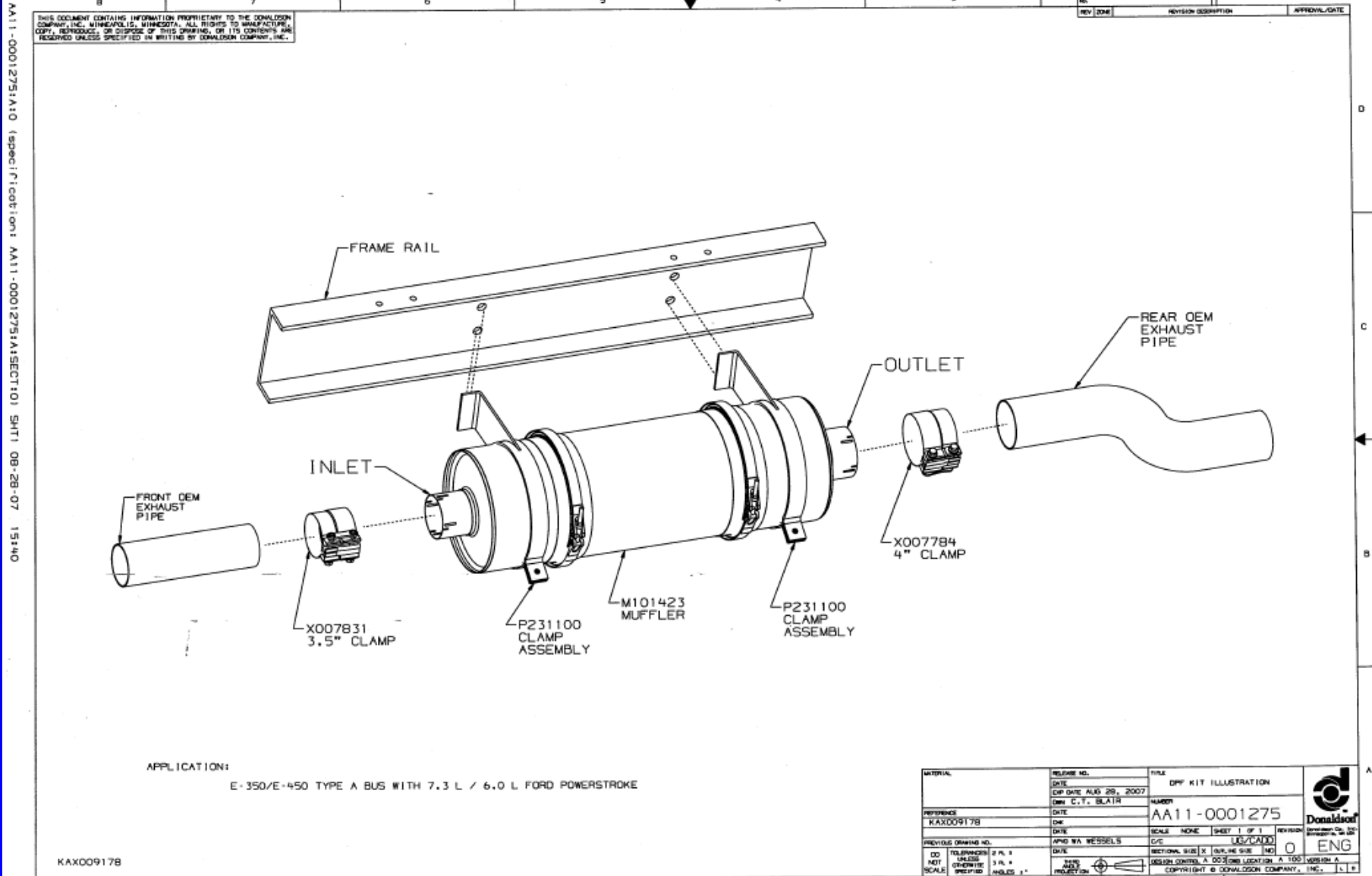
<b>DPF Muffler Kits</b>				
Inlet I.D.	Outlet I.D.	Body Length	Body Dia.	Kit No.
<b>&lt; 1450 CFM (~250 HP)</b>				
<b>Style 1</b>				
3.0'	3.0'	30.0'	10.0'	X009223
3.5'	4.0'	30.0'	10.0'	X009178
<b>&lt; 1700 CFM (~300 HP)</b>				
<b>Style 1</b>				
4.0'	4.0'	36.0'	11.0'	X007858
4.0'	4.0'	36.0'	11.0'	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
<b>Style 2</b>				
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
<b>Style 3</b>				
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
<b>Style 4</b>				
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
<b>Style 6</b>				
5.0'	5.0'	36.0'	11.0'	X009239



# Muffler Styles



# Installation Kit



KAX009178



# Emissions Technology Operation

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



# Summary

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