

Emissions Retrofit Solutions for On-Road Diesel-Powered Vehicles

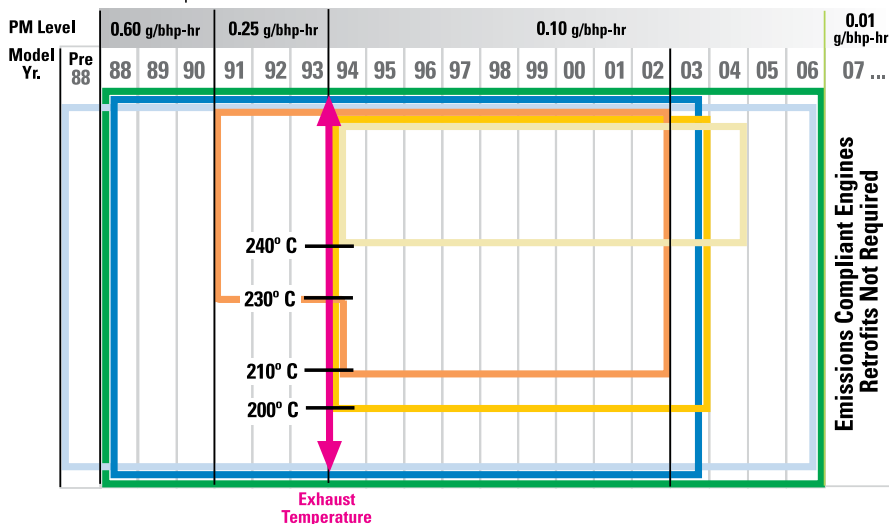
Donaldson was the first to introduce tailpipe and crankcase retrofit solutions in support of the U.S. EPA & California ARB voluntary diesel retrofit programs.

Color Legend:
The colored outlines within the model year chart below represent a Donaldson retrofit solution.

DPF Mufflers	DMF Mufflers
LTF Mufflers	DOC and DOC Mufflers
Active DPF Muffler	DOC Mufflers + Spiracle

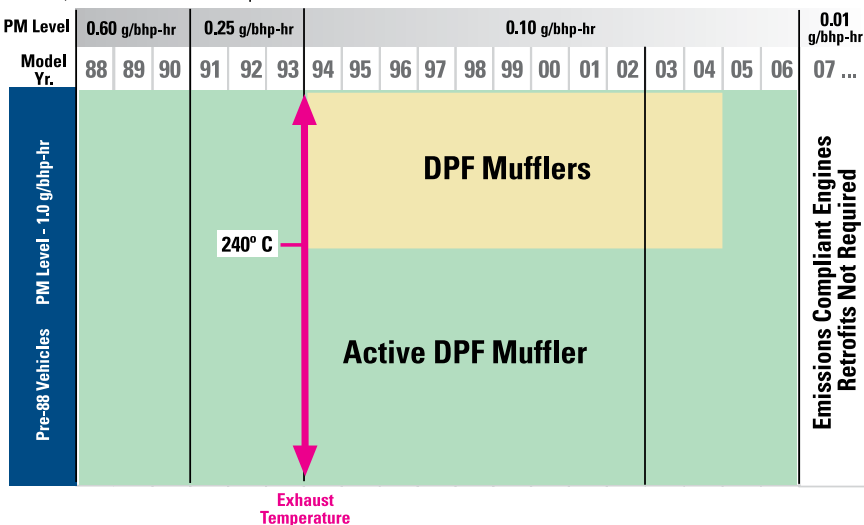
Verified Product Coverage by Engine Model Year

4-stroke 150-600 horsepower



California ARB Bact Product Coverage

On-road, 4-stroke 150-600 horsepower



Verifications

California ARB Site: <http://www.arb.ca.gov/diesel/verdev/verdev.htm>

U.S. EPA Diesel Retrofit Web Site: www.epa.gov/otaq/retrofit/retroverifiedlist.htm

Latest Solutions...

- Plastic Spiracle CFS...pursuing verification
- LTF Muffler - pursuing verification
- Active DPF Muffler - pursuing verification

DPF Muffler (Non-EGR)

- CARB EO DE-04-005-02 - Level 3 (2005)
- CARB EO DE-04-005-01 - Level 3 (2004)
- CARB EO DE-04-005 - Level 3 (2004)

DMF Muffler

- CARB EO DE-05-012 - Level 2 (2005)

DMF Muffler with Spiracle CFS

- CARB EO DE-05-013 - Level 2 (2005)

DOC Muffler (Series 6400) with Spiracle CFS

- CARB EO DE-04-009-01 - Level 1 (2006)

DOC Muffler (Series 6400)

- CARB EO DE-04-010-01 - Level 1 (2006)

DOC Muffler (Series 6000)

- CARB EO DE-04-009 - Level 1 (2004)
- CARB Verification Letter off-road (May 2003)
- EPA non-EGR (2003)

DOC Muffler (Series 6000) with Spiracle CFS

- CARB EO DE-04-010 - Level 1 (2004)
- EPA non-EGR (2003)

DOC Mufflers (Series 6100)

- CARB Verification Letter - Level 1 (Nov. 2002)
- EPA (Aug. 2003)

DOC Mufflers (Series 6100) with Spiracle CFS

- CARB Verification Letter - Level 1 (Nov. 2002)

Donaldson tailpipe and crankcase solutions are patented and patent pending.

Left to right: Spiracle CFS, DPF Muffler, DMF Muffler, LTF Muffler, DOC Muffler



Basic Technology Comparison by Product Type

Product Family	Spiracle™ Crankcase Filtration System	DPF or LTF ⁽¹⁾ Mufflers	Active DPF System ⁽¹⁾	DMF Mufflers	DOC Mufflers
Technology	Barrier	Wall Flow	Flow Through + Wall Flow ⁽²⁾	Multiple Stage Partial Filter	Flow Through
PM Efficiency (%)	100%	90+%	90+%	71-75%	20-30%
with Spiracle CFS	--	90-95%	90-95+%	75-80%	25-49%
BACT/BART Level		Level 3 (>85%)	Level 3 (>85%)	Level 2 (>50%)	Level 1 (>25%)
Temperature Sensitivity	None	Low ⁽³⁾ - Medium	None	Low	None
Fuel Type	Any	ULSD	Any	ULSD	Any
Install Time ⁽⁴⁾	2-5 hrs	2-4 hrs	3-5 hrs	1-3 hrs	1-3 hrs

Efficiency and Cost Comparison by Technology

Based on FTP test cycle: 25% of emissions come from the crankcase, 75% from the tailpipe.

Emissions Technology	Highest Efficiency with Routine Maintenance (Level 3)				High Efficiency with Minimal Maintenance (Level 2)				Cost-Effective with Minimal Maintenance (Level 1 w/Spiracle CFS)				
	Diesel Particulate Filter		Diesel Multi-Stage Filter		Diesel Oxidation Catalyst		Diesel Oxidation Catalyst		Diesel Oxidation Catalyst		Diesel Oxidation Catalyst		
Donaldson Product Family	DPF or LTF Muffler		DPF or LTF Muffler with Spiracle™ CFS		DMF Muffler		DMF Muffler with Spiracle™ CFS		DOC Muffler		DOC Muffler with Spiracle™ CFS		
Emissions Reduction (ER) and Relative Contribution (RC) to Emissions Reduction	ER	RC	ER	RC	ER	RC	ER	RC	ER	RC	ER	RC	
Tailpipe Emissions	75%	85%	64%	85%	64%	70%	53%	70%	53%	20%	15%	20%	15%
Crankcase Emissions	25%	0%	0%	100%	25%	0%	0%	100%	25%	0%	0%	100%	25%
Total Emissions Reduced %	64%		89%		53%		78%		15%		40%		
Installed Cost⁽⁵⁾	\$8,000 - \$11,000				\$6,000 - \$8,000				\$2,000 - \$4,000				
Cost Per % of Emissions Reduced	\$125 - \$171		\$99 - \$123		\$113		\$102		\$133		\$100		

(1) Pursuing verification.

(2) Active DPF System uses two filters (SiC DPF and DOC) and requires electricity and compressed air for periodic on-board regeneration.

(3) Low Temperature Filter (LTF) Muffler use two filters to extend the operating temperature range.

(4) Actual install time varies by application and installer; excludes logistics.

(5) Costs shown include installation and are for comparative purposes only, actual costs may vary. Spiracle CFS system installed cost range is \$800 - \$1,200.

Spiracle CFS (crankcase filtration system) is registered trademark of Donaldson Company, Inc.



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