



Retrofit Technology Basics and Keys to Success

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Diesel Engine

- **Workhorse engine used throughout the world**
- **A high torque engine**
- **Spins slower than gasoline or electric power systems**
- **Produces significantly less CO than gasoline powered vehicles – Last to control from EPA**
- **Exceptional longevity – can often perform for 40+ years**

Air Pollutants

- **Particulate matter (PM), including PM_{2.5}**
- **Unburned hydrocarbons**
- **Nitrogen oxides (NOx)**
- **Some carbon monoxide (CO)**
- **Hazardous air pollutants (HAPs)**
 - ▤ Aldehydes
 - ▤ PAHs

EPA Verified Technologies

Verified Technologies | Diesel Retrofit Technology Verification | US EPA - Microsoft Internet Explorer

Address: http://www.epa.gov/otaq/retrofit/verif-list.htm

U.S. ENVIRONMENTAL PROTECTION AGENCY

Diesel Retrofit Technology Verification

Search: All EPA This Area

You are here: [EPA Home](#) > [Transportation and Air Quality](#) > [National Clean Diesel Campaign](#) > [Diesel Retrofit Technology Verification](#) > Verified Technologies

Verified Technologies

The table below lists the diesel retrofit technologies that EPA has approved for use in engine retrofit programs. The manufacturer link in the table may be selected to learn more about the retrofit technology and its operating criteria. The table shows the percent reduction (of verified or tested levels) that EPA will recognize for emission reductions for each technology. See the [retrofit manufacturers contact](#) page for more information on these manufacturers.

Each technology listed here meets the new NO₂ emission limits that took effect January 2009. For information on the technologies that were removed from this table see the [list of technologies that were formerly approved](#). [More information on NO₂ limits](#).

[General statement regarding emissions from platinum-based fuel additives \(PDF\)](#) (1 pg, 108K, EPA420-B-08-014, July 2008).

You will need Adobe Reader to view some of the files on this page. See [EPA's PDF page](#) to learn more.

Verified Retrofit Technologies

Manufacturer	Technology	Applicability	Reductions (%)			
			PM	CO	NOx	HC
BASF (formerly listed under Engelhard)	CMX Catalyst Muffler	Highway, heavy-duty, 4 cycle engines	20	40	n/a	50
Caterpillar, Inc.	Diesel Particulate Filter	Nonroad, 4 cycle, non-EGR equipped, model year 1996-2005, turbocharged engines with power ratings 130 ≤ KiloWatts < 225 (174.2 ≤ Horsepower < 301.5)	89	90	n/a	93
Caterpillar, Inc.	Emissions Upgrade Group	Nonroad: Caterpillar model 3306 diesel engines for nonroad applications with model years from 1988 to 1995 with mechanical direct fuel injection.	22	13	37	71
Cummins Emission Solutions	Cummins Emission Solutions & Cummins Filtration Diesel Oxidation Catalyst (DOC) and Closed Crankcase Ventilation (CCV) System ET ✓	Highway, heavy-heavy and medium-heavy duty, 4 cycle, non-EGR, model year 1991 - 2003, turbocharged or naturally aspirated engines	30 ^a	50	n/a	74
Donaldson	Series 6000 DOC & Spiracle (closed crankcase filtration system) ET ✓	Highway, heavy heavy- and medium heavy-duty, 4-cycle, non-EGR, model year 1991 - 2003, turbocharged or naturally aspirated engines	25 to 33 ^a	13 to 23	n/a	50 to 52
Donaldson	Series 6100 DOC ET ✓	Highway, heavy heavy- and medium heavy-duty, 4-cycle, non-EGR, model year 1991 - 2003, turbocharged or naturally aspirated engines	20 to 26	38 to 41	n/a	49 to 66
Donaldson	Series 6100 DOC & Spiracle (closed crankcase filtration)	Highway, heavy heavy- and medium heavy-duty, 4-cycle, non-EGR, model year 1991 - 2003,	28 to 33 ^a	31 to 34	n/a	42

Internet

Closed Crankcase Ventilation (CCV)

- Crankcase emission (blow-by) is the result of high pressure gases and oils escaping around the piston rings and venting into the atmosphere
- Natural occurrence in diesel engines
- Crankcase emissions were not included in EPA engine certification test protocol until 2007



Closed Crankcase Ventilation (cont'd)

- **Blow-by gases are taken directly from the engine to the breather assembly**
- **Heavy oil and aerosol particles are captured, separated and coalesced by the media material**
- **Filters up to 99% of oil drip and 95% of aerosol vapors from blow-by**
- **Eliminates 100% of engine compartment fumes 3-5% PM reduction ***

* Not EPA/CARB verified as a stand-alone product

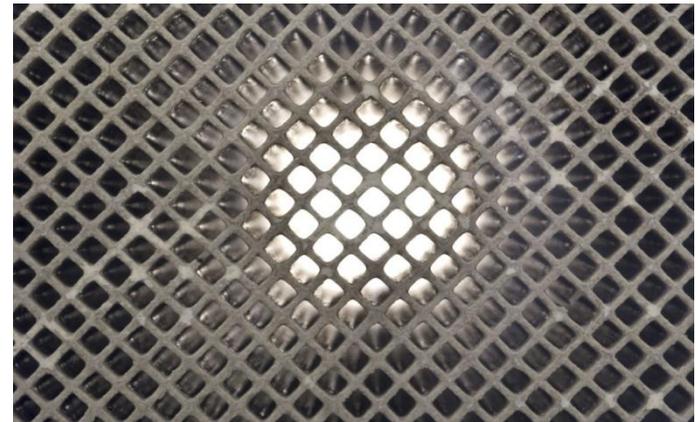
Closed Crankcase Ventilation (cont'd)

- **Compact design mounts easily in engine compartment**
- **Coalescing filter must be changed once a year, or every 1,500 hours (school bus) or 1,000 hours (all other applications)**
- **Engine operating temperatures must be at least 150 degrees Celsius during the duty cycle**
- **Standard Kit usually comes with:**
 - Coalescing filter assembly
 - Crankcase depression regulator valve and bracket
 - Oil drain-back to engine oil sump
- **1991 – 2003 engines**

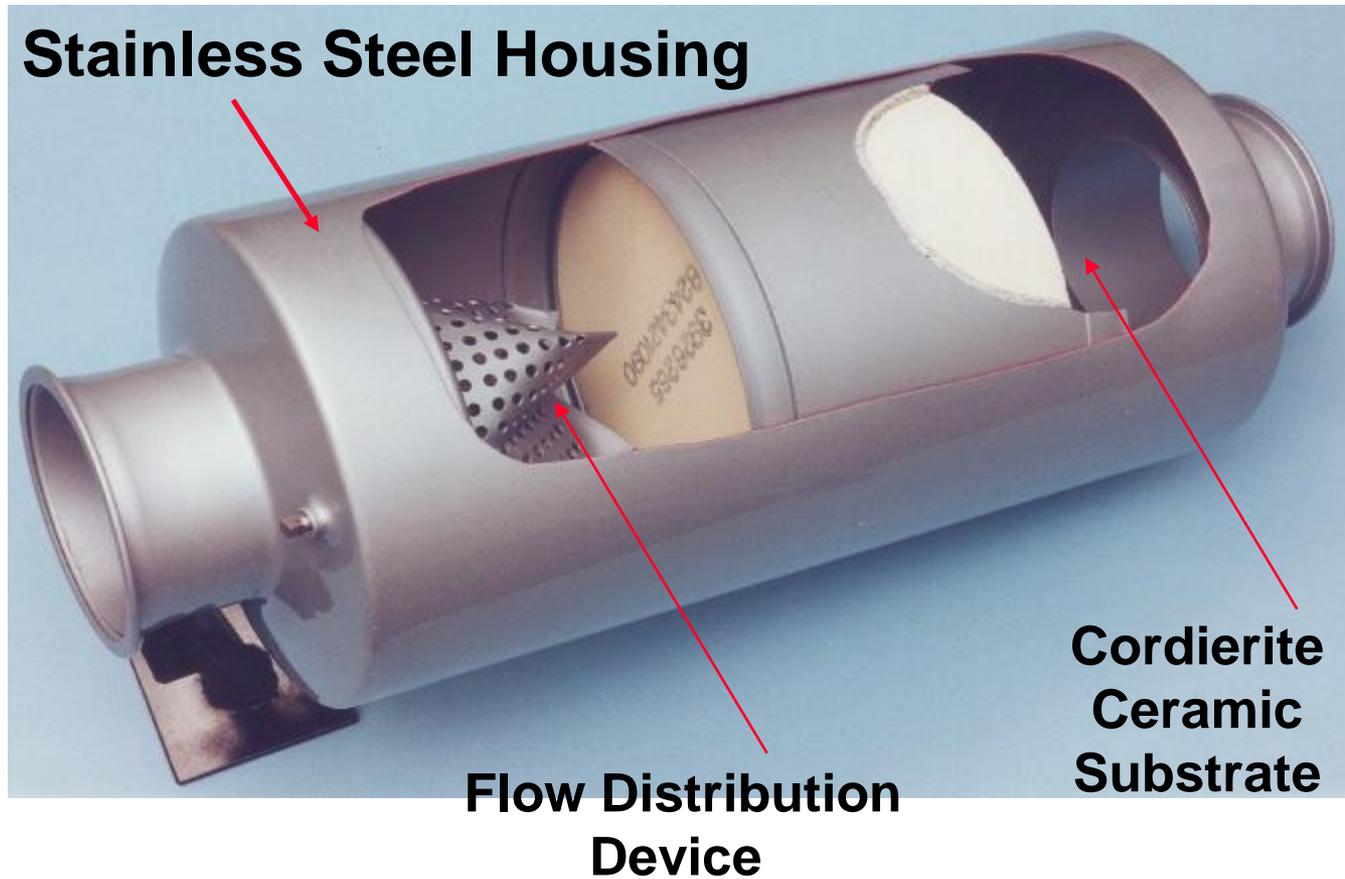


Diesel Oxidation Catalyst (DOC)

- **Flow-through device designed to replace the existing muffler system**
- **Effective at removing unburned fuel and lube (soluble organic fraction) from exhaust**
- **Emissions reductions:**
 - PM 20-30%
 - CO & HC > 50%
 - NO_x None



Diesel Oxidation Catalyst (DOC)



Diesel Oxidation Catalyst (cont'd)

- **Compatible with low sulfur (< 500 ppm) and ultra low sulfur (<15 ppm) diesel fuel**
- **Does not require a minimum operating temperature**
- **Maintenance-free design is easy to install and requires no monitoring**
- **1993 and newer engines**



DOC + CCV

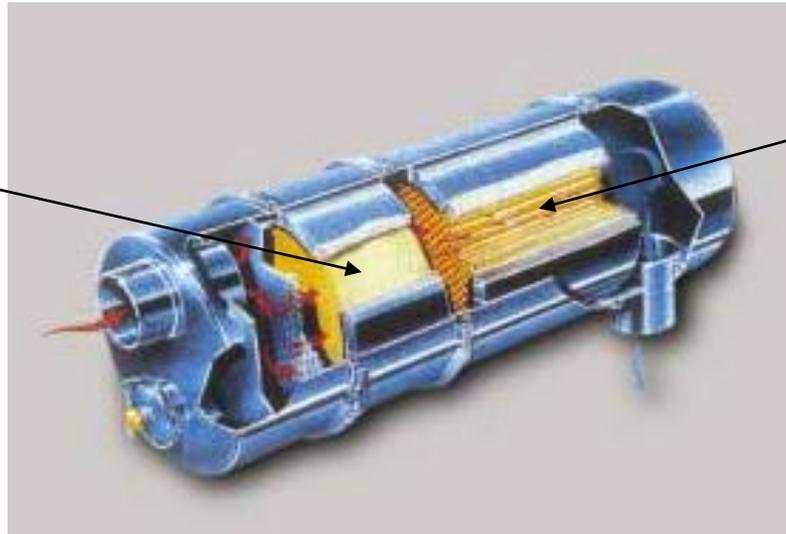
- **Tailpipe and crankcase emissions combined**
- **DOC + CCV verified emissions reduction *:**
 - PM 30%
 - CO 50%
 - HC 74%
- **Engine operating temperatures must be at least 150 degrees C during the duty cycle**

* Must be used in conjunction with ULSF to achieve these emissions reductions

Diesel Particulate Filter (DPF)

- **Passive retrofit system that traps and oxidizes soot before turning it to ash**
- **Patented Johnson Matthey design utilizes two chambers**

A portion of NO in the exhaust is oxidized to create NO₂



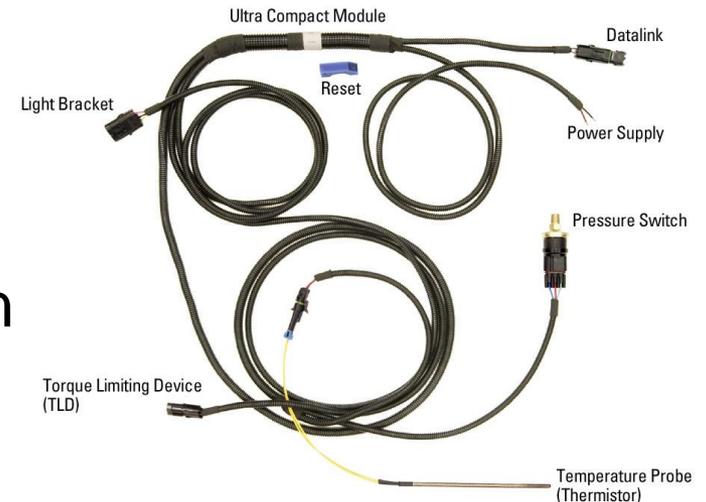
Exhaust flows through a wall-flow filter; soot is trapped and destroyed by the NO₂ product

Diesel Particulate Filter (cont'd)

- **Provides the best emissions reductions**
 - PM 90%
 - CO 85%
 - HC 95%
- **Designed to replace the existing muffler system**
- **DPF kit comes with:**
 - Complete two-stage catalytic filter
 - Monitor and sensors
 - Noise control built in
 - Exhaust piping and mounting brackets

Diesel Particulate Filter (cont'd)

- **Monitoring is required for use with a DPF**
- **UCM monitors filter backpressure and temperature and sends a fault code if outside of acceptable operating parameters**
- **Reduces the risk of:**
 - **Plugging**
 - **Uncontrolled regeneration**
 - **Catalyst poisoning / deactivation**
 - **Engine progressive damage**



Diesel Particulate Filter (cont'd)

- **Ultra low sulfur fuel is required**
- **Must be data logged prior to installation to insure minimum operating temperatures are met**
 - CRT: 240 degrees C for 40% of operating time
 - CCRT: 200 degrees C for 40% of operating time
 - ❖ May be used with up to B20 biodiesel
 - ❖ 1991 and newer engines in good operating condition
 - ❖ Filter element must be cleaned every 60 –100k miles or as indicated by the UCM

Retrofit Product Summary

Technology	PM	CO	HC	Maintenance	ULSD
CCV	3-5%	n/a	n/a	Replace CCV filter	No
DOC	20%	50%	50%	No	No
DOC + CCV	30%	50%	74%	Replace CCV filter	Yes
DPF	90%	85%	95%	Clean filter section	Yes

Select the Right Technology for your Fleet

- **Several EPA web sites offer advice on selection methodology**
- **Consult with RI DEM or MACTEC on recommendations based on individual application**
- **Not appropriate for certain vehicles**
- **No one size fits all**



Installation

- **Professionals only**
- **Installation at the end of the tailpipe could be disastrous (too much cooling)**
- **Could have significant impact on engine performance if not installed properly**
- **Trained technicians essential**
- **RI DEM has reference list of experienced installers**

Maintenance

- **Must be properly maintained**
- **Essential that maintenance personnel receive proper training on repairs and maintenance of equipment**
- **A number of consultants offer specific training for individual repair/maintenance shops**
- **Several web seminars available**
- **Not a lot of published material on servicing**

Monitoring Devices

- **Off-the-shelf equipment sold that generally pays off in assuring performance**
- **Data loggers used to track relevant performance information**
- **Testing for pollutants not needed**

Summary

- **Certainly helps mitigate emissions from a large on-road motor pool**
- **Very effective in reducing black smoke and other particulates emanating from diesel exhaust**
- **Does not reduce NO_x significantly**
- **Control technology matched with individual use type**

Information Sources

Northeast Diesel Collaborative

<http://www.northeastdiesel.org>

US EPA National Clean Diesel Campaign

<http://www.epa.gov/cleandiesel>

Diesel Technology Forum

<http://www.dieselforum.org/meet-clean-diesel>

Manufacturers of Emission Controls Association

<http://www.meca.org>